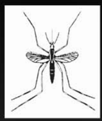
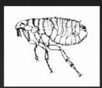
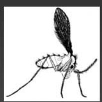
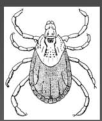
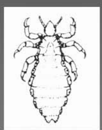
Office of the Deputy Under Secretary of Defense for Installations & Environment

Regional
Disease Vector Ecology Profile

Caribbean

Defense Pest Management Information Analysis Center
Armed Forces Pest Management Board
Forest Glen Section
Walter Reed Army Medical Center
Washington, DC 20307-5001

Homepage: http://www.afpmb.org

July 2002

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 around the world. Primary emphasis is on the epidemiology of arthropod-borne diseases and the bionomics and control of disease vectors. DVEPs have proved 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 plan and implement prevention and control measures to protect deployed forces from disease, injury, and annoyance caused by vector and pest arthropods. 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 hantavirus and 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.
Additional information on venomous vertebrates and noxious plants is available in the Armed Forces Medical Intelligence Center's (AFMIC) Medical, Environmental, and Disease Intelligence, and Countermeasures (MEDIC) CD-ROM.

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

Defense Pest Management Information Analysis Center (DPMIAC) Services: In addition to providing DVEPs, DPMIAC publishes Technical Guides (TGs) and the Military Pest Management Handbook (MPMH). DPMIAC 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 DPMIAC at Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7473. Additional hard copies or diskettes of this publication are also available.

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 Armed Forces Medical Intelligence Center (AFMIC), Fort Detrick, Frederick, MD 21701, Tel: (301) 619-7574, DSN: 343-7574.

Vector Risk Assessment Profiles (VECTRAPs) for most countries in the world can be obtained from the Navy Preventive Medicine Information System (NAPMIS) by contacting the Navy Environmental Health Center (NEHC) at Tel: (757) 762-5500, after hours at (757) 621-1967, DSN: 253-5500, or Fax: (757) 444-3672. Information is also available from the Defense Environmental Network and Information Exchange (DENIX). The homepage address is: <http://denix.army.mil/denix/denix.html>.

Specimen Identification Services: Specimen identification services and taxonomic keys can be obtained from the Walter Reed Biosystematics Unit (WRBU), Museum Support Center, MRC-534, Smithsonian Institution, Washington, DC 20560 USA; Tel: (301) 238-3165; Fax: (301) 238-3667; e-mail: <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 the following Emergency Supply Operations Centers (ESOCs) to provide equipment and supplies to deploying forces:

> **For insect repellents, pesticides and pesticide application equipment:** Contact the Defense Supply Center Richmond ESOC at Tel: (804) 279-4865, DSN: 695-4865. The ESOC is staffed seven days a week/24 hours a day. Product Manager (804) 279-3995, DSN: 695-3995.

> **For personal protection equipment (bednets, headnets, etc.) and respirators:** Contact the Defense Supply Center Philadelphia ESOC Customer Assistance Branch at Tel: (215) 737-3041/3042/3043, DSN: 444-3041/3042/3043.

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, DPMIAC, Armed Forces Pest Management Board, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC 20307-5001, Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7482.

Acknowledgments: The initial draft of this DVEP was prepared by Dr. John B. Gingrich, LTC USA (retired), Dr. Harold J. Harlan, LTC USA (retired), Dr. Peter V. Perkins, COL USA (retired) and Dr. James H. Trosper, CDR USN (retired). Subsequent technical reviews and recommendations were provided by DPMIAC's Dr. Richard G. Robbins and CDR George W. Schultz, USN. Additional reviews were provided by COL Phillip G. Lawyer, USA, and Dr. Timothy H. Dickens, CDR USN (retired), as well as by the personnel of the Armed Forces Medical Intelligence Center. The cover design is the work of Mr. J. Rees Stevenson of DPMIAC. Experts were consulted for the taxonomic accuracy of respective arthropod groups discussed in the DVEP. COL Phillip G. Lawyer (USUHS) and Dr. Peter V. Perkins reviewed the sand flies. Dr. Roy McDiarmid, National Museum of Natural History, reviewed the snakes. MAJ Scott A. Stockwell, 25th Medical Unit Commander, Ft. Hood, TX, reviewed the scorpions, and Mr. James Pecor of the U.S. Army Walter Reed Biosystematics Unit reviewed the mosquitoes.

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EXECUTIVE SUMMARY

Caribbean Profile.

Geography. The Caribbean Islands are situated primarily within the tropics, between 10° and 26° north latitude, and nearly all have a humid tropical climate. They extend in a large arc from the Yucatan peninsula of Mexico and the Florida peninsula to the northeastern coast of Venezuela. The four largest islands, called the Greater Antilles, in order from west to east are Cuba, Jamaica, the island of Hispaniola (comprising the countries of Haiti and the Dominican Republic), and Puerto Rico. The Bahamas and the Turks and Caicos Islands are two groups of several hundred mainly small islands, scattered in an arc north of the Greater Antilles, beginning east of the tip of Florida and ending north of Hispaniola. Starting east of Puerto Rico, most of the remaining Caribbean islands form an arc southward, ending with Aruba and Trinidad and Tobago just off the northeast coast of Venezuela. These small islands, called the Lesser Antilles, are geographically separated into the Leeward chain and the Windward chain. All of the larger and most of the smaller islands are mountainous, mainly of volcanic origin, with usually cooler temperatures and greater rainfall at higher elevations. The highest point in the Caribbean is 3,175 m at Pico Duarte near the center of the western half of the Dominican Republic. The lowest point in all these islands is -46 m elevation at Lago Enriquillo, also in the Dominican Republic near the country's western land border with Haiti. The three largest countries (Cuba, the Dominican Republic, and Haiti) occupy about 81% of the total combined land area of all the Caribbean islands and have more than 72% of the total population of this region. Cuba is the largest country in this region with more than 110,000 sq km of land area. It is slightly smaller than Pennsylvania and more than twice as large as the second largest Caribbean island country, the Dominican Republic, which has a little more than 48,000 sq km of land area.

Historically, the economic base for most of these countries was sugarcane, an industry dependent on slaves brought from Africa, primarily during the 17th and 18th centuries. When slavery was abolished in most of this region in the mid-1800s, most of these countries suffered economic collapse. Recent declines in world sugar prices coupled with weather problems (especially tropical storms) have hurt many island economies. New industries, such as tourism, offshore financial and business services, petroleum refining, processing and transshipment, and light manufacturing, and the development of other agricultural crops have recently begun to revive the regional economy. Currently, tourism is the primary source of income of most Caribbean nations. Food, machinery, fuel and most consumer goods must be imported. Natural hazards include hurricanes for 21 countries, periodic droughts for 8 countries, flooding for at least 5 countries, volcanic activity for 6 countries, and occasional earthquakes or landslides in at least 4 countries. Montserrat has experienced a major, continuing eruption of a volcano in the Soufriere Hills that began in 1997. This has devastated much of the island, causing two-thirds of the former population to leave. Several Caribbean countries have high unemployment. Most people are of African ancestry and practice a variety of religions, though Roman Catholicism remains predominant.

Climate. All Caribbean countries have tropical or subtropical climates that are usually moderated by trade winds or ocean currents. Higher elevations are cooler and receive more rainfall. In general, the eastern and southern coasts of most of these islands tend to be wetter and to have less seasonal temperature variation. Puerto Rico is an exception because of its topography and the direction of prevailing trade winds. It has fairly constant rainfall, but its southern coast is much drier than its northern coast. There is usually a wet season (sometimes only a little wetter) from May to October, with threats of tropical storms or hurricanes from June through November. Many Caribbean islands also have a distinct dry season, usually from January to March or April. Temperatures for the region typically range from 22ºC to 30ºC year-round, with few high or low extremes and little seasonal variation. Cuba and the northern Bahamas may sometimes experience winter temperatures as low as 15ºC for brief periods under the usually temporary influence of cold air masses from North America. Average annual rainfall may vary from 90 cm per year on some islands to more than 180 cm per year on others. A typical average for most Caribbean islands is about 145 cm per year. Droughts can be severe in limited areas, although heavy rains can cause local flash floods and occasional landslides that increase erosion.

Population and Culture. Cuba has the largest population, with more than 11 million persons. Barbados has the highest population density at slightly more than 638 persons per sq km, while the Bahamas have the lowest population density at just over 29 persons per sq km. Together, Cuba, the Dominican Republic, and Haiti account for more than 72% of the total population of this region. The people of the Cayman Islands have the longest life expectancy at birth (78.9 years), while the people of Haiti have the shortest life expectancy (49.2 years). At least 14 of the 25 countries in the Caribbean have literacy rates of 95% or more. The Caribbean is characterized by people of diverse ethnic backgrounds due to intermarriage. The majority of the Caribbean population is derived from African slaves brought to work the sugarcane fields and other agricultural enterprises. The vast majority (more than 75%) of the regional population is Roman Catholic; Anglican and other Protestant denominations constitute most of the remainder. Some countries, such as Trinidad & Tobago, have significant numbers of Hindus and Muslims. In Haiti, people commonly practice Voodoo or other native cult or folk rituals. In recent years, educational opportunities have increased significantly for women, who now actively participate in business, politics and the professions. The average life expectancy at birth has been increasing and is greater than 70 years in all but three countries (Haiti, Grenada, and Trinidad and Tobago).

Sanitation and Living Conditions. Most people in the Caribbean enjoy a fair to good standard of living. Most of the individual countries' economies are growing slowly, although some, such as Puerto Rico, are growing rapidly and a few, like Haiti, may be stagnant or declining. Haiti is one of the poorest countries in the Western Hemisphere. Most Haitians cannot afford health care. The United Nations has reported that 80% of Haiti's people live in abject poverty and cannot even meet their own daily needs; yet, rich plantation owners own luxury cars and often send their children to expensive foreign colleges. Availability of adequate to good communications, transportation, electronic devices, and consumer goods varies throughout the region, but these amenities are accessible to most people, especially in or near urban centers. Availability of good medical care, adequate roads, airports, and communications facilities varies widely within the Caribbean; rural areas often are impoverished. Medical care (based on U.S. standards) and availability varies from high quality in Puerto Rico to inadequate or virtually unavailable in Haiti. The inequity of income is a source of political tensions. A significant shortage of potable drinking water is a serious problem in many areas of the Caribbean due to expanding populations and agricultural demands. Many Caribbean countries have water and sewage treatment systems that are inadequate and poorly maintained. Discharge of raw sewage or industrial waste is common. Poor sanitation and contamination of drinking water and food are common. Consequently, food-borne and water-borne diseases, including hepatitis A, typhoid fever and enteric bacterial diseases, are a serious public health problem. Ciguatera poisoning is a perennial threat in the Caribbean. It is caused by eating commonly caught reef fish (such as snapper, grouper, etc.) that have consumed dinoflagellates and other algae that contain a toxin. The risk is not reduced by cooking the fish. Ecological concerns on most Caribbean islands include coastal pollution from spilled oil or sewage dumped from ships (which can kill local fish and coral and prevent swimming by tourists), deforestation, soil erosion, and threats to the remaining environmentally sensitive areas. Marine hazards include the Portuguese man-of-war, stingrays, several species of poisonous fish, stinging anemones and jellyfish, and sharp corals, present in most coastal waters.

DIARRHEAL DISEASE

Gastrointestinal infections are highly endemic throughout the Caribbean and are the principal disease threats to military personnel deployed to the region. Risk is very high in Haiti but significantly lower in most other parts of the Caribbean. Food and beverages are generally safe to consume in most resort areas but should be considered unsafe in rural areas, particularly in impoverished parts of the Caribbean. Bacillary dysentery has had a profound impact on military operations throughout history.

Fecal-oral transmission from person to person is common, but most infections are acquired from the consumption of contaminated food, water or ice. Filth flies can be important in the mechanical transmission of pathogens to food, food preparation surfaces and utensils. Fly populations sometimes reach very high levels during the summer in areas with poor sanitation. Strict sanitation and fly control can significantly reduce the risk of gastrointestinal infections. **Consult TG 30, Filth Flies: Significance, Surveillance and Control in Contingency Operations**. Cockroaches have also been shown to mechanically transmit gastrointestinal pathogens.

Bacteria and viruses causing diarrheal disease include: *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus*, *Vibrio parahaemolyticus*, numerous serotypes of *Salmonella*, *Shigella* spp., *Campylobacter*, pathogenic strains of *Escherichia coli*, hepatitis A and E, rotaviruses, and other viral species. Rotavirus is the most common causative agent of nonspecific diarrhea in children in the Caribbean. Infection with pathogenic protozoa, such as *Entamoeba histolytica*, *Giardia lamblia* and *Cryptosporidium* spp., is common, though bacterial pathogens account for 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.

Typhoid and paratyphoid fevers are also endemic; cholera has not been reported recently from the Caribbean, but outbreaks have occurred in nearby Mexico and Central America. Resistance of enteric pathogens to commonly used antibiotics can complicate treatment, and antibiotic-resistant pathogens have been reported from the region.

MOSQUITO-BORNE DISEASE*

Malaria has been eradicated throughout the Caribbean except for the island of Hispaniola. Malaria is a major public health problem in Haiti, where risk is present countrywide and year-round at elevations under 500 m. Risk of transmission is higher in the northern parts of Haiti. Malaria occurs in rural areas of the Dominican Republic below 400 m, especially in the provinces bordering Haiti. In both countries, nearly all cases are caused by *Plasmodium falciparum*. Drug-resistant strains are not a problem and chloroquine is currently recommended for prophylaxis. An outbreak of vivax malaria occurred on Trinidad in the early 1990s, and a cluster of malaria cases caused by *P. malariae* also occurred on Trinidad during the mid 1990s. Current risk of transmission on Trinidad is unknown but is likely to be very low. Competent malaria vectors are present on most Caribbean islands, and imported cases of malaria are common.

Dengue is widespread throughout the Caribbean, including dengue hemorrhagic fever/dengue shock syndrome, and outbreaks occur annually. All 4 serotypes of dengue virus are circulating in the region. In Cuba, major epidemics have resulted in several hundred thousand cases. The introduction and spread of *Aedes albopictus* in the Caribbean region will increase the risk of transmission. Dengue is the most serious arthropod-borne disease risk to military personnel in the Caribbean.

Yellow fever is not a threat to military personnel in the Caribbean due to the low enzootic prevalence of the disease, which may circulate only in forested areas of Trinidad, and the availability of a safe vaccine that provides complete protection against infection with yellow fever virus.

Epizootics of **mosquito-borne viral encephalitis**, including eastern equine encephalitis, St. Louis encephalitis, Venezuelan equine encephalitis and western equine encephalitis, have occurred in the Caribbean, although few human cases have been reported. Of these, Venezuelan equine encephalitis appears to be the most prevalent, although the epidemiology of these arboviruses is poorly known in the region. Risk of transmission appears to be low. Numerous potential vector species, especially in the genus *Culex*, are widely distributed in the Caribbean.

Filariasis, caused by nocturnally periodic *Wuchereria bancrofti*, is prevalent in Haiti and the Dominican Republic. Filariasis transmission may occur in the Lesser Antilles from Trinidad to Guadeloupe, although incidence of the disease in these islands is rare. The primary if not exclusive vector in most parts of the Caribbean is *Culex quinquefasciatus*.

TICK-BORNE DISEASE*

Tick-borne diseases are an insignificant threat to military personnel in the Caribbean. In 1999, a single case of **African tick bite fever** caused by *Rickettsia africae* was reported from a tourist who had visited Guadeloupe in the French West Indies. The pathogen was also isolated from the tropical bont tick, *Amblyomma variegatum*, collected on the island. In 1987, a case of **tick-borne-relapsing fever** was reported in a park ranger working in the Virgin Islands. Several species of *Ornithodoros* soft ticks are known from the Caribbean, and many of these are common in caves found on many islands. Human cases of **Q fever** have not been reported from the Caribbean recently. However, livestock on Trinidad have been found infected with *Coxiella burnetii*, and the pathogen is probably focally distributed throughout the Caribbean wherever livestock are raised. Troops should avoid consumption of local unpasteurized dairy products and contact with domestic animals. Soldiers should not rest, sleep, or work in or near animal sheds or other areas where livestock have been housed.

SAND FLY-BORNE DISEASE*

Cutaneous leishmaniasis (CL) is rare in the Caribbean. At least two species of *Leishmania* cause skin lesions on certain islands of the region. The only country with a current focus of cutaneous leishmaniasis is the Dominican Republic. Most of the cases are of the diffuse clinical type and tend to be negative for the Montenegro skin test, but mild, subclinical cases are apparently common. In the Dominican Republic the black rat, *Rattus rattus*, has been incriminated as a reservoir of *Leishmania mexicana dominica*. The suspected sand fly vector of *Le. mexicana dominica* in the Dominican Republic is *Lutzomyia christophei*, the only anthropomorphic species on the island. CL may be present in Haiti, but no recent studies have confirmed this. Sporadic indigenous cases of CL have also been reported in Martinique and in Trinidad. Human cases were reported in Trinidad before 1930, but it is not clear if they represent endemic human CL or if they were imported cases. No new cases have been found in the last 70 years, although an enzootic cycle is present on Trinidad involving rodent and marsupial reservoirs, the sand fly *Lu. flaviscutellata*, and the parasite *Le. amazonensis* or a closely related species. Sporadic cases of CL have been reported on Martinique, where *Lu. atroclavata* has been identified as the only indigenous sand fly. No autochthonous cases have been documented in Cuba, although the sand fly *Lutzomyia orestes* is common in all the provinces of Cuba and is known for persistent and vicious attacks on humans. Consequently, the opportunity for introduction of CL into Cuba is high compared to other islands of the Caribbean. Puerto Rico has had numerous imported cases of CL, but the ecology on this island seems to be unfavorable for endemic transmission because no anthropophilic sand fly species has been found. **Visceral leishmaniasis (VL)** is essentially unknown from the Caribbean. One apparently indigenous case of VL was reported in Guadeloupe in 1966. However, there have been no recent studies to confirm if VL is endemic on the island.

CULICOIDES*-BORNE DISEASE

Mansonellosis is caused by infection with the filarial worms *Mansonella ozzardi* or *M. perstans* and is largely nonpathogenic. Microfilariae of *Mansonella* spp. circulating in the peripheral blood may be mistaken for microfilariae of more serious filarial pathogens such as *Wuchereria bancrofti*. Human infection is highly prevalent in Haiti and the Dominican Republic. Transmission also occurs on some islands of the Lesser Antilles as well as on Trinidad and Tobago. *Culicoides* midges, especially *C. furens*, are the vectors. These midges are so small that they can easily pass through the standard mesh size of window screens and bed nets.

TRIATOMINE-BORNE DISEASE*

Since 1960, *Trypanosoma cruzi*, blood-sucking triatomine vectors, and wild animals infected with the parasite have been reported from the islands of Aruba, Curaçao, Jamaica, and Trinidad and Tobago in the Caribbean. Competent vectors also occur on several other Caribbean islands. The risk of **Chagas' disease** is highest on Trinidad, but some serological surveys in the 1990s indicate that transmission to humans occurs at extremely low levels. Some triatomines, also known as kissing bugs, have painful bites. *Trypanosoma cruzi* is difficult to detect in the bloodstream and may be transmitted through blood tranfusions.

SNAIL-BORNE DISEASE

The risk of infection with *Schistosoma mansoni* in the Caribbean is currently confined to freshwater, primarily in parts of the Dominican Republic, Guadeloupe, Martinique, Montserrat, Puerto Rico, and St. Lucia. Prevalence of **schistosomiasis** on Montserrat is low, and the disease is under control on St. Lucia. Only a few cases of schistosomiasis are annually diagnosed on Martinique. Recent serological surveys indicate that the prevalence of schistosomiasis on Puerto Rico greatly diminished during the 1990s. Untreated individuals can remain infected for many years. Cases often are not diagnosed until after returning from endemic areas. Military personnel should avoid contact with potentially contaminated water.

RODENT-BORNE DISEASE

Leptospirosis should be considered enzootic in most countries of the Caribbean. 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.

CONJUNCTIVITIS

Bacterial and viral **conjunctivitis** is common in the Caribbean and has epidemic potential. Several outbreaks of acute hemorrhagic conjunctivitis caused by enterovirus 70 and coxsackievirus A24 have occurred in the Caribbean. Prevention and early detection are important, because no effective treatment exists. Trachoma caused by *Chlamydia trachomatis* has been demonstrated in patients in Haiti and may be present in other impoverished parts of the Caribbean. Transmission is normally through contact with secretions of infected persons or contaminated articles. Eye gnats and flies can mechanically transmit these pathogens.

VENOMOUS ANIMALS

At least 8 species of **poisonous terrestrial snakes** are sufficiently venomous to be of concern to medical personnel. They are not widely distributed in the Caribbean, and many islands have no venomous snakes. Consequently, snakebite is not a serious risk 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. Effective snake antivenins are available. **Scorpions, centipedes**, **widow spiders (*Latrodectus* spp.) and recluse or violin spiders (*Loxosceles* spp.)** are common in many parts of the Caribbean. *Scolopendra* species of centipedes can attain a length of over 25 cm and inflict a very painful bite. There are numerous **scorpions** in the Caribbean. The scorpions *Centruroides gracilis*, *C. griseus*, *C. trinitatis*, *Tityopsis obtusus* and *T. trinatis* are medically important species and occur on Cuba, Martinique, Puerto Rico, Trinidad and Tobago, and possibly other islands. Their venom may cause a variety of painful symptoms in humans, including acute heart problems, cardiac histopathology, as well as pancreatic and neurological involvement. Severest symptoms occur in small children and the elderly. Most scorpion stings do not require hospitalization, and death is rare, although envenomization by widow spiders can be life threatening. Antivenins are available. Troops should be warned not to tease or play with snakes and scorpions. **Marine hazards** include the Portuguese man-of-war, stingrays, several species of poisonous fish, stinging anemones and jellyfish, and sharp corals, which are present in coastal waters.

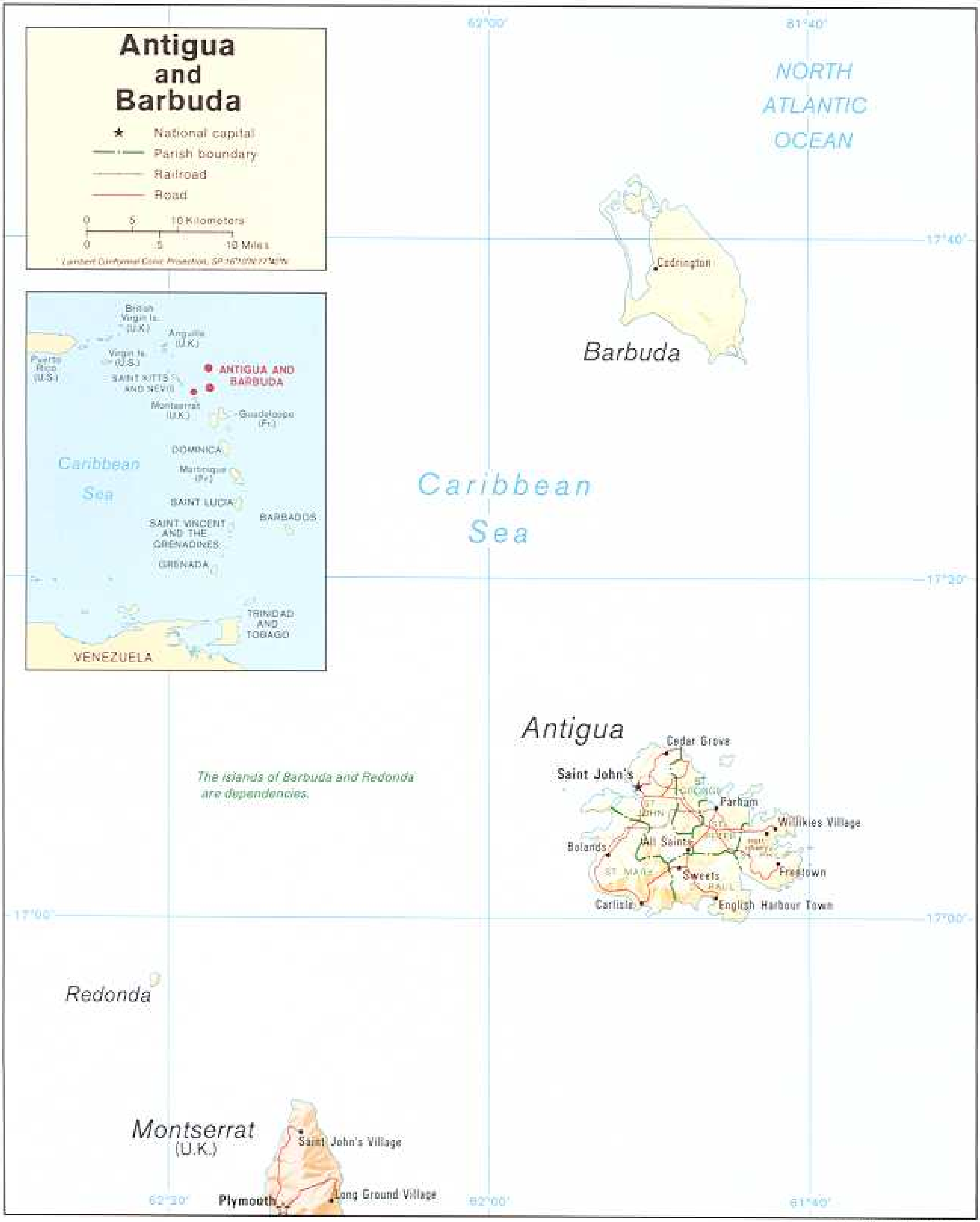
*** A properly worn Battle Dress Uniform (BDU) impregnated with permethrin, combined with use of extended duration DEET on exposed skin, has been demonstrated to provide nearly 100% protection against most blood-sucking arthropods. This dual use of highly effective repellents on the skin and clothing 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.**

VECTOR-BORNE DISEASES IN THE CARIBBEAN (+ = present; ? = uncertain).

Diseases	Anguilla	Antigua & Barbuda	Aruba	Barbados	Bahamas	Cuba	Curaçao	Dominica	Dominican Republic	Grenada	Guadeloupe	Haiti	Jamaica	Martinique	Montserrat	Netherlands Antilles	Puerto Rico		St. Kitts & Nevis St. Lucia	St. Martin	St. Vincent	Trinidad	Virgin Islands
malaria						?			+			+										+	
dengue	+	+	+	+	+	+		+	+	+	+	+	+	+		+	+	+	+	+	+	+	+
yellow fever																						?	
eastern equine encephalitis						+			+			?	+									+	
St. Louis encephalitis													+									+	
Venezuelan equine encephalitis				+	+	+															+	+	
boutonneuse fever											+												
Q Fever												?	?									+	?
relapsing fever (tick-borne)																	?						+
Chagas' disease			?				?						?									+	
cutaneous leishmaniasis									+		?	?		?								+	
visceral leishmaniasis											?												
schistosomiasis		+							+		+	?		+	+		+		+				

filariasis									+		?	+										?	
mansonellosis		+		+				+	+	+	+	+		+					+		+	+	
leptospirosis				+				+	+			+	+	+					+		+	+	

The Caribbean



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0 50 100 Miles
UNITED STATES (Florida)
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Walker's Cay
Grand Bahama
Cornishtown
Freeport
Hope Town
Moore's Island
Abaco
BIMINI ISLANDS
Great Harbour Cay
North Cat Cay
South Cat Cay
South Riding Rocks
Orange Cay
Dunmore Town
Eleuthera
Current Island
Governors Harbour
Nicholls Town
NASSAU
New Providence
Andros Town
Highbourn Cay
Norman's Cay
Hawksbill Cay
Waderick Wells Cay
Arthur's Town
Cat Island
New Bight
NORTH ATLANTIC OCEAN
Andros Island
Congo Town
Great Guana Cay
Cockburn Town
San Salvador
Conception Island
Rum Cay
Elbow Cay
DAMAS CAYS
(THE BAHAMAS)
ANGUILLA CAYS
Georgetown
Great Exuma
Long Island
Clarence Town
JUMENTOS CAYS
Flamingo Cay
Samana Cay
Crooked Island
Colonel Hill
Guinchos Cay (THE BAHAMAS)
Seal Cay
Nurse Cay
Mayaguana
Abraham's Bay
Acklins Island
Cay Lobos (THE BAHAMAS)
Ragged Island
Santa Clara
Cienfuegos
Sancti Spíritus
Ciego de Ávila
CUBA
Cay Verde
Hogsty Reef
Little Inagua
Cay Santo Domingo (THE BAHAMAS)
Nuevitas
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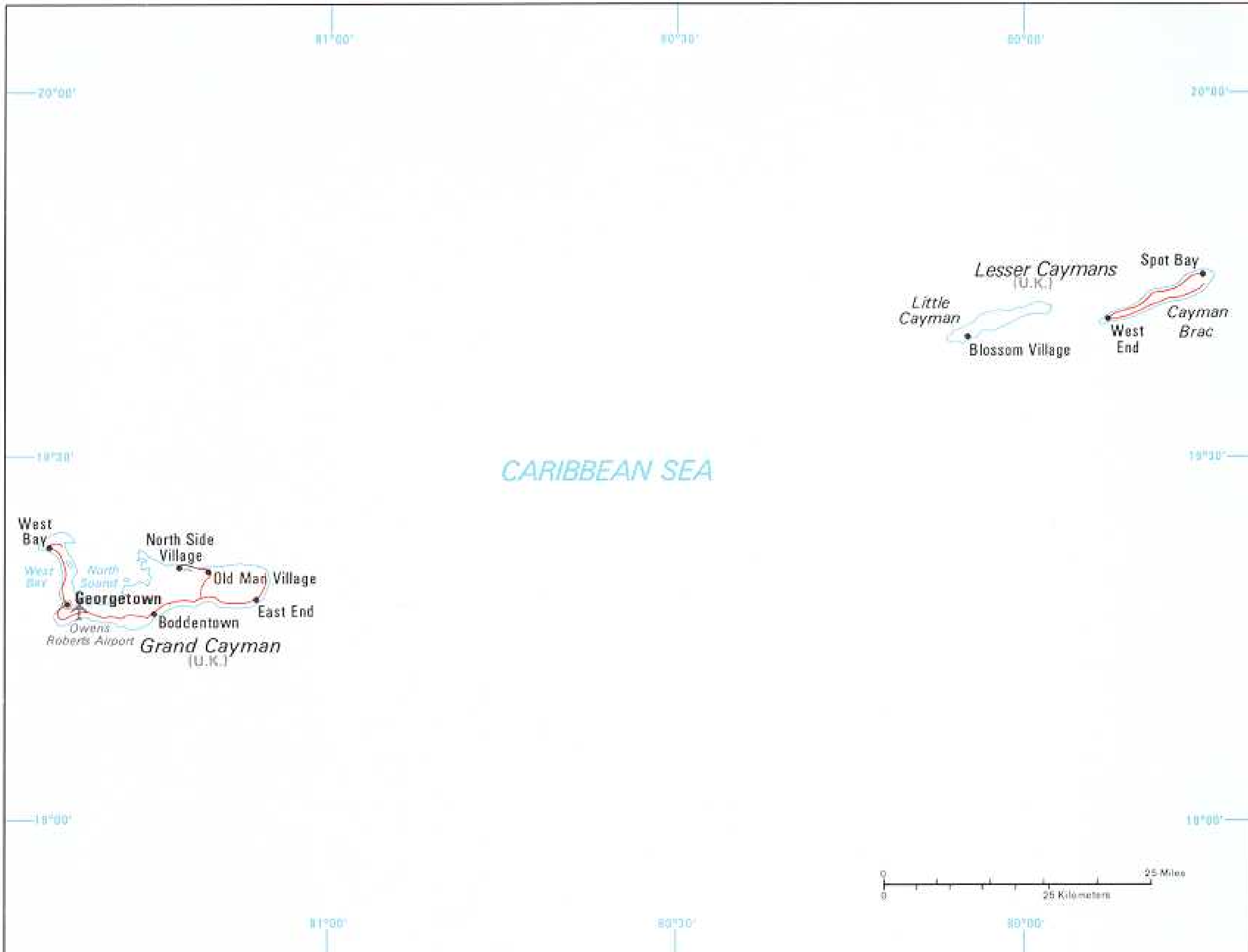
Base 504291 2-80

Cayman Islands

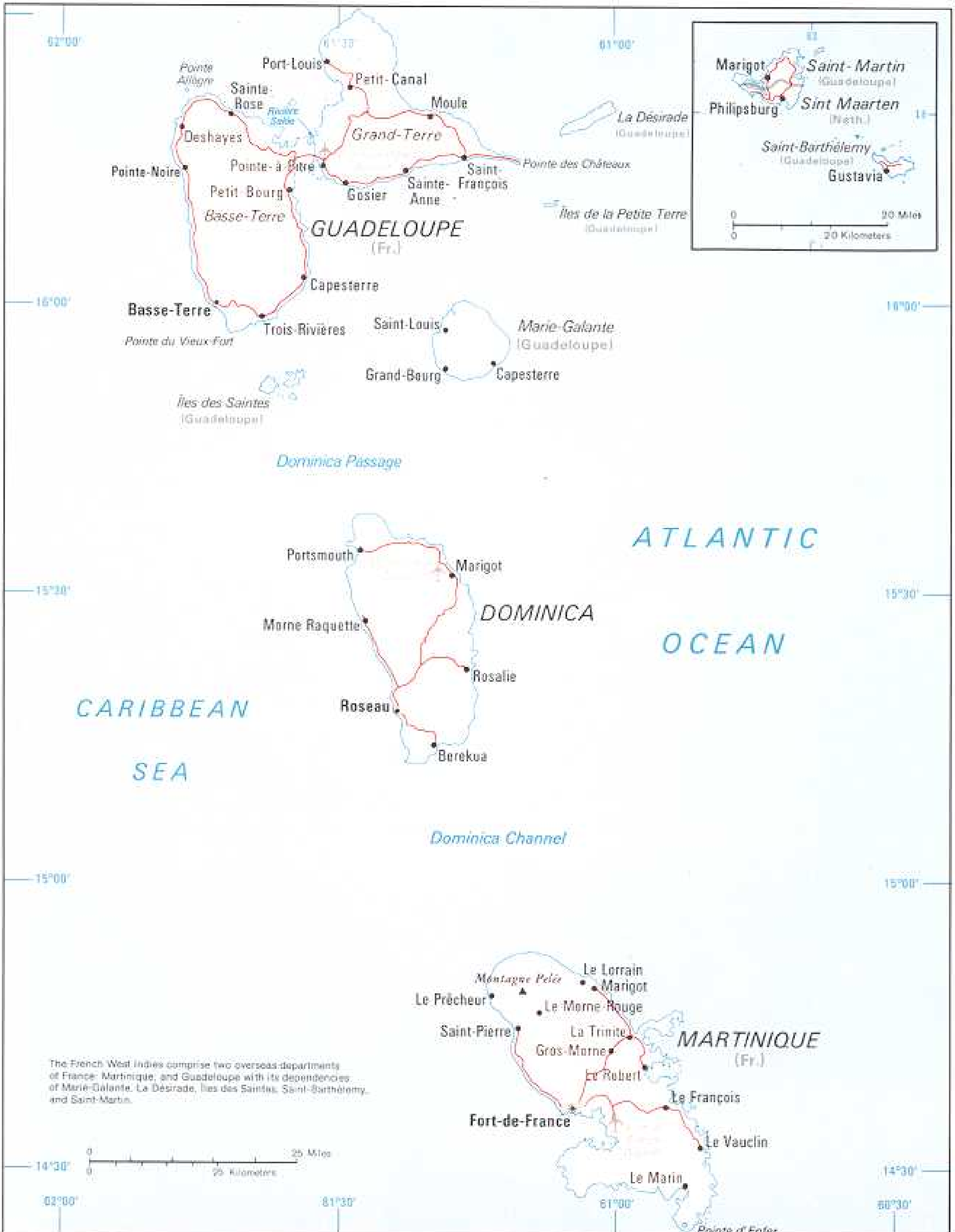


502490 1-76 (541654)
Lambert Conformal Projection
Standard Parallels 17°20' and 22°40'
Scale 1:875,000

Road
Airport

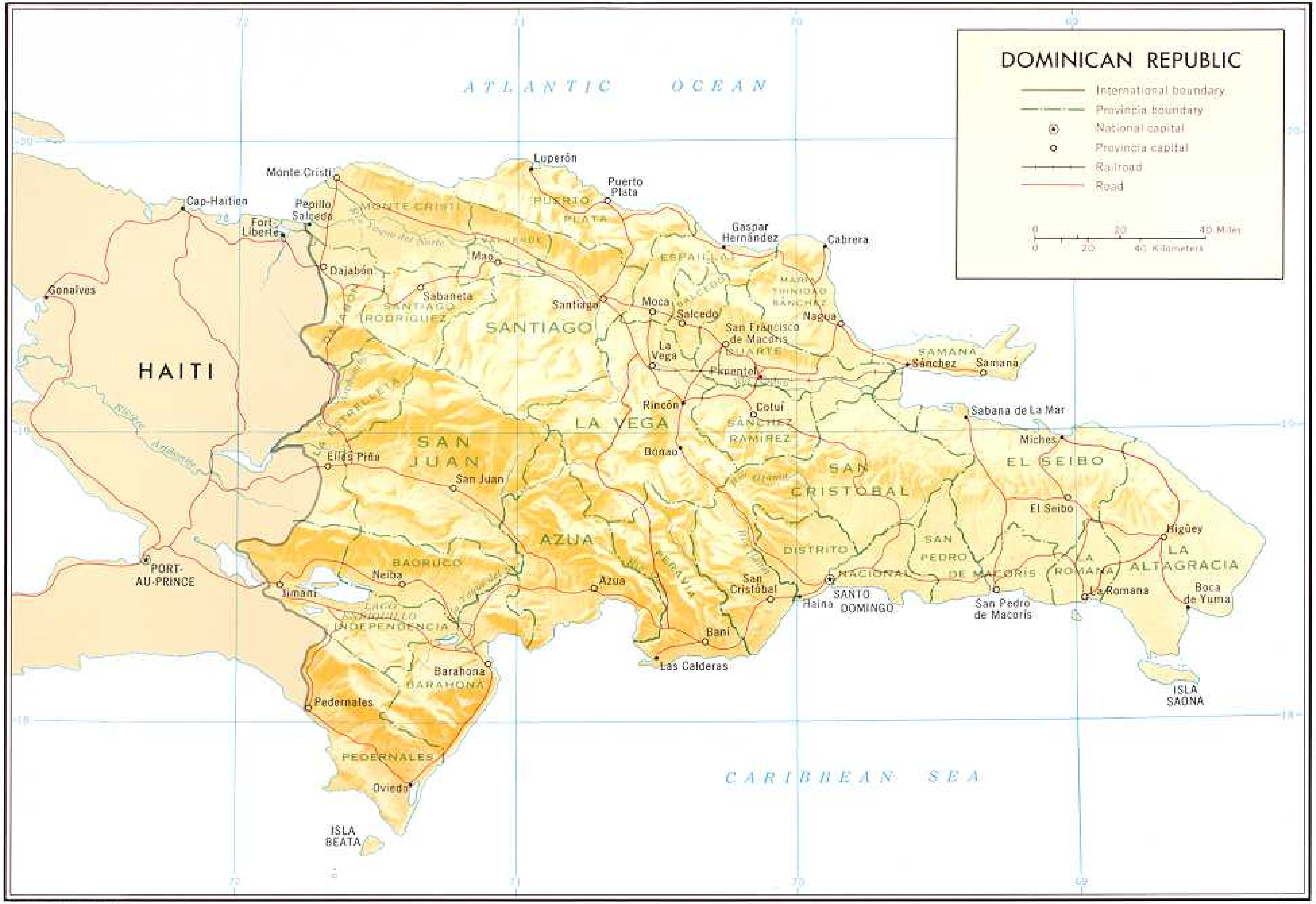

Cuba
Line of separation
National capital
Province boundary
Province capital
Railroad
Expressway
Road
0 50 100 Kilometers
0 50 100 Miles
Gulf of Mexico
Straits of Florida
Yucatan Channel
Caribbean Sea
NORTH ATLANTIC OCEAN
Windward Passage
U.S.
Homestead
Key Largo
Marathon
Key West
FLORIDA KEYS
THE BAHAMAS
Nassau
New Providence
Eleuthera
Andros Island
EXUMA CAYS
Cat Island
San Salvador
Great Exuma
Rum Island
Long Island
Crooked Island
Acklins Island
JUMENTOS CAYS
RAGGED ISLAND RANGE (THE BAHAMAS)
Cay Santo Domingo (THE BAHAMAS)
Great Inagua
Cay Sal Bank (THE BAHAMAS)
Guinchos Cay (THE BAHAMAS)
Cay Lobos (THE BAHAMAS)
ARCHIPIÉLAGO DE SABANA
ARCHIPIÉLAGO DE CAMAGÜEY
ARCHIPIÉLAGO DE LOS JARDINES DE LA REINA
Havana
CIUDAD DE LA HABANA
LA HABANA
Mariel
Artemisa
Güira de Melena
Güines
Surgidero de Batabanó
Matanzas
Cárdenas
Jovellanos
Colón
MATANZAS
Aguada de Pasajeros
CIENFUEGOS
Cienfuegos
VILLA CLARA
Isabela de Sagua
Caibarién
Santa Clara
Placetas
Sancti Spíritus
SANCTI SPIRITUS
CIEGO DE AVILA
Morón
Ciego de Avila
Florida
Nuevitas
Camagüey
CAMAGUEY
Santa Cruz del Sur
Puerto Padre
Las Tunas
LAS TUNAS
Amancio
Holguín
HOLGUIN
Banes
Antilla
Mayarí
Moa
Baracoa
GUANTANAMO
Guantánamo
U.S. Naval Base Guantanamo Bay
Manzanillo
Bayamo
GRANMA
Palma Soriano
Santiago de Cuba
SANTIAGO DE CUBA
Pilón
Minas de Matahambre
San Cristóbal
Arroyos de Mantua
PINAR DEL RIO
Pinar del Río
La Fe
Isabel Rubio
Golfo de Batabanó
Nueva Gerona
La Fe
ISLA DE LA JUVENTUD
(special municipality)
Isla de la Juventud
Cayo Largo
Little Cayman
Cayman Brac
Grand Cayman
George Town
Cayman Islands (U.K.)
JAMAICA
Montego Bay
Ocho Rios
Port Antonio
Kingston
Savanna la Mar
Spanish Town
Navassa Island (U.S.)
HAITI
Cayes

Dominica, Guadeloupe, and Martinique



502451 1-76 (541881)
Lambert Conformal Projection
Standard parallels 14°40' and 16°10'
Scale 1:1,100,000

Road
Airport


DOMINICAN REPUBLIC
International boundary
Provincia boundary
National capital
Provincia capital
Railroad
Road
0 20 40 Miles
0 20 40 Kilometers
ATLANTIC OCEAN
CARIBBEAN SEA
HAITI
Cap-Haitien
Gonaives
PORT-AU-PRINCE
Monte Cristi
Pepillo Salcedo
Fort-Liberte
Dajabón
Luperón
Puerto Plata
Gaspar Hernández
Cabrera
Mao
Sabaneta
Santiago
Moca
Salcedo
Nagua
San Francisco de Macoris
La Vega
Pimentel
Sánchez
Samaná
Rincón
Cotuí
Sabana de La Mar
Miches
Bonao
Elías Piña
San Juan
Jimaní
Neiba
Azua
Baní
Las Calderas
San Cristóbal
Haina
SANTO DOMINGO
San Pedro de Macorís
El Seibo
Higüey
La Romana
Boca de Yuma
ISLA SAONA
Barahona
Pedernales
Oviedo
ISLA BEATA
MONTE CRISTI
PUERTO PLATA
ESPAILLAT
SALCEDO
MARIA TRINIDAD SANCHEZ
SANTIAGO
SANTIAGO RODRIGUEZ
DUARTE
SAMANA
LA VEGA
SAN JUAN
SANCHEZ RAMIREZ
SAN CRISTOBAL
EL SEIBO
AZUA
BAORUCO
PERAVIA
DISTRITO NACIONAL
SAN PEDRO DE MACORIS
LA ROMANA
LA ALTAGRACIA
INDEPENDENCIA
BARAHONA
PEDERNALES
Base 78965 10-70

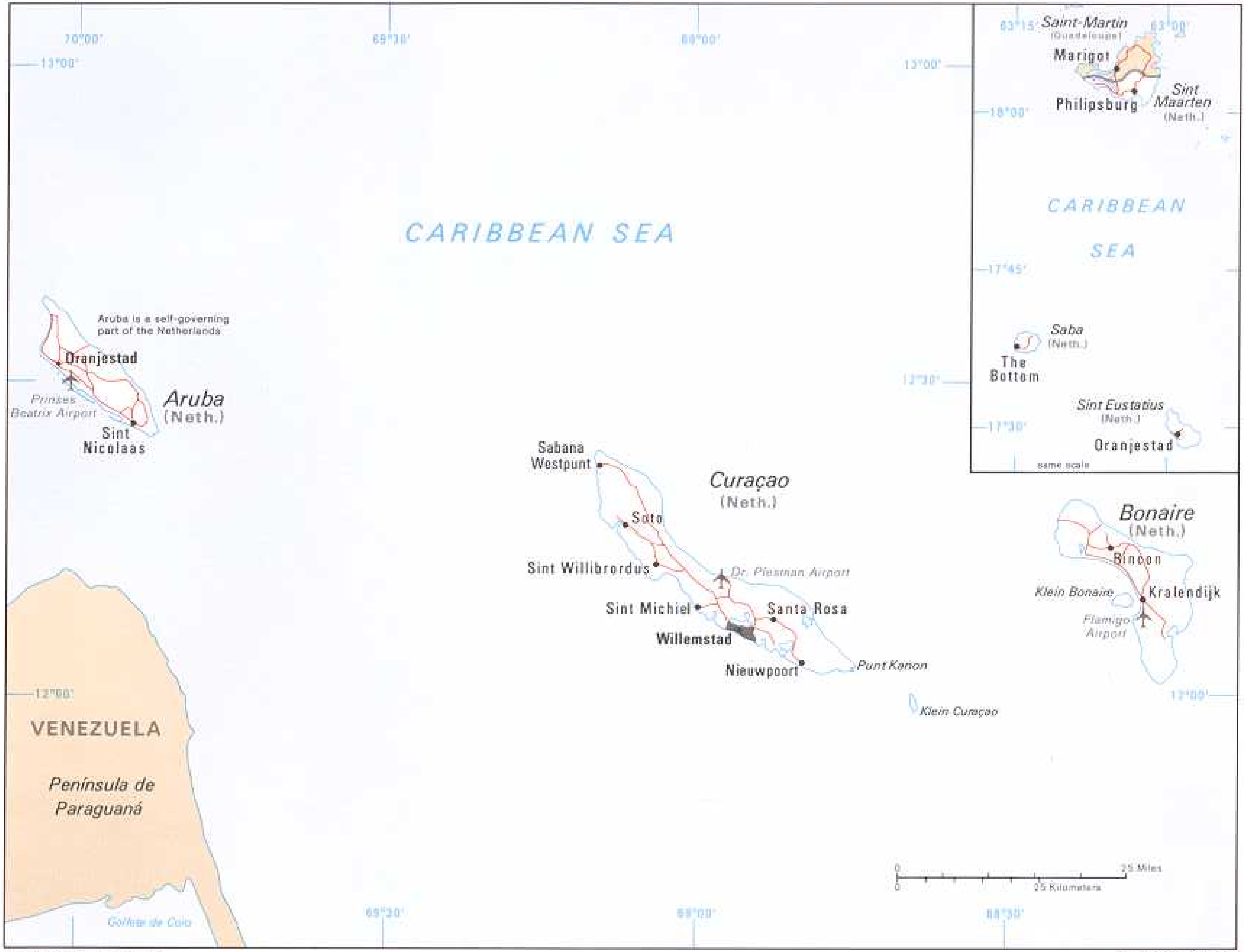
Base 801602 (546324) 6-90

Haiti
International boundary
Department boundary
National capital
Department capital
Road
0 10 20 30 40 Kilometers
0 10 20 30 40 Miles
Mercator Projection
CUBA
Cayo Babo
Windward
Passage
Île de la
Tortue
NORTH ATLANTIC OCEAN
Port-de-Paix
Le Borgne
NORD-OUEST
Môle
Saint-Nicolas
Baie de
Henne
Cap-Haïtien
Limbé
NORD
Grande Rivière
du Nord
NORD-
EST
Monte Christi
Pepillo
Salcedo
Fort-Liberté
Dajabón
Ennery
Gonaïves
Saint-
Raphaël
Golfe
de la
Gonâve
ARTIBONITE
Lafond
Saint-Marc
Hinche
Hispaniola
Verrettes
CENTRE
Caribbean
Sea
Montrouis
Canal de
Saint-Marc
Île de
la Gonâve
La Cayenne
Anse à
Galets
Comendador
San
Juan
Mirebalais
DOMINICAN
REPUBLIC
OUEST
Jérémie
Grande
Cayemite
Canal du Sud
Baie de
Port-au-Prince
Manneville
Dame-
Marie
Petit Trou
de Nippes
Port-au-Prince
Croix de
Bouquets
Anse d'Hainault
Pestel
Léogâne
Pétionville
Jimaní
GRAND'ANSE
Petite Goâve
Lago
Enriquillo
Miragoâne
Kenscoff
Trouin
Duvergé
Les Anglais
SUD
Aquin
SUD-EST
Jacmel
Marigot
Belle-Anse
Les Cayes
Côtes-de-
Fer
Bainet
Port-Salut
Île à Vache
Pedernales
Caribbean Sea
Enriquillo


JAMAICA
Parish boundary
National capital
Parish capital
Railroad
Road
0
10
20 Miles
0
10
20 Kilometers
CARIBBEAN SEA
CARIBBEAN SEA
HANOVER
WESTMORELAND
SAINT JAMES
TRELAWNY
SAINT ANN
SAINT MARY
SAINT ELIZABETH
MANCHESTER
CLARENDON
SAINT CATHERINE
SAINT ANDREW
KINGSTON
PORTLAND
SAINT THOMAS
Lucea
Negril
Savanna la Mar
Montego Bay
Reading
Montpelier
Falmouth
Runaway Bay
Saint Anns Bay
Ocho Rios
Oracabessa
Port Maria
Annotto Bay
Moneague
Christiana
Frankfield
Chapelton
Linstead
Bog Walk
Port Antonio
Half Way Tree
KINGSTON
Spanish Town
May Pen
Old Harbour
Mandeville
Black River
Alligator Pond
Morant Bay
18°30'
18°00'
78°00'
77°30'
77°00'
76°30'
Base 58783 11-68

Leeward Islands

Netherlands Antilles and Aruba



Lambert Conformal Projection
Standard parallels 11°30' and 13°30'
(inset 17°15' and 18°15')
Scale 1:1,000,000

801359 (541677) 6-89

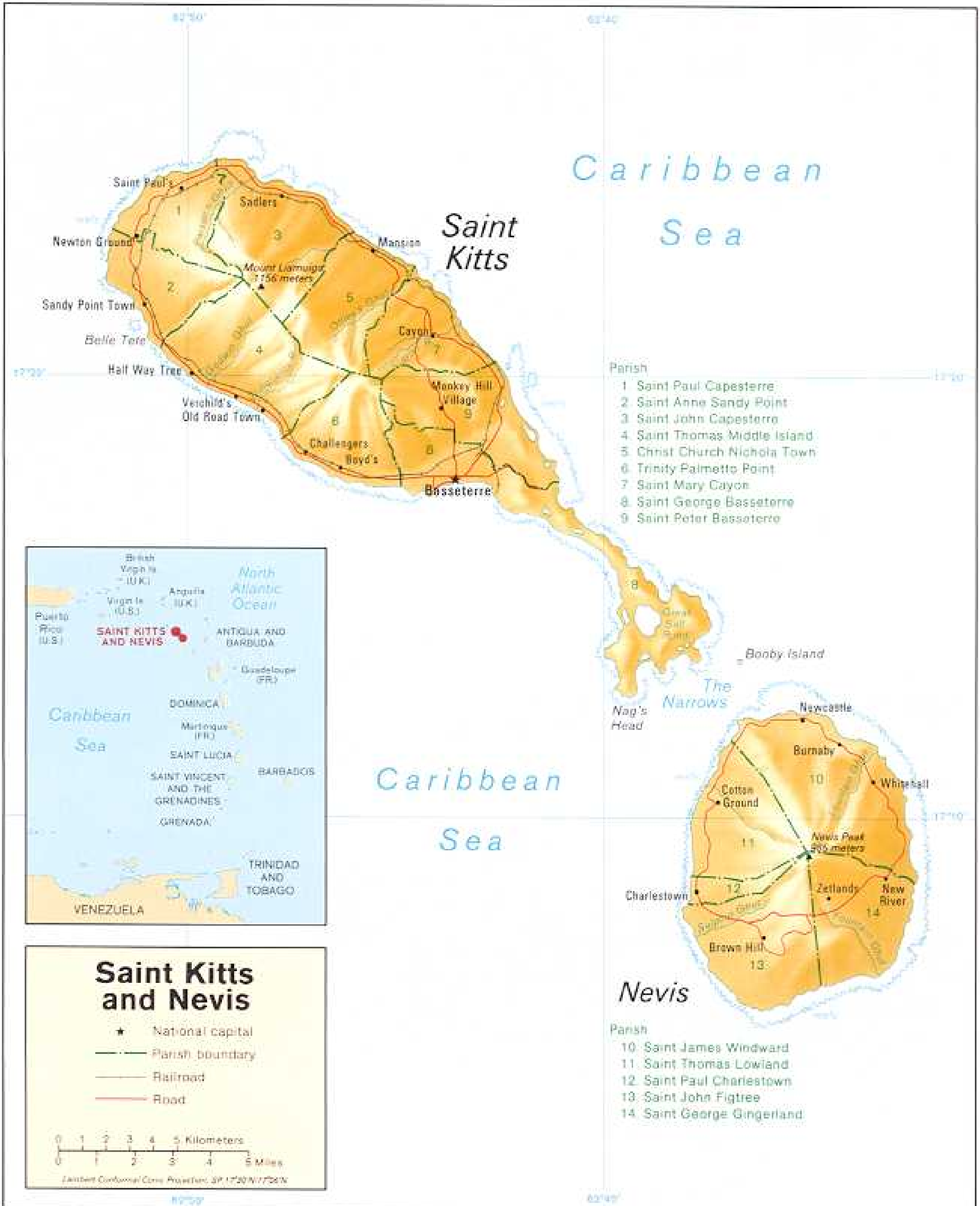
Road

Airport

Puerto Rico

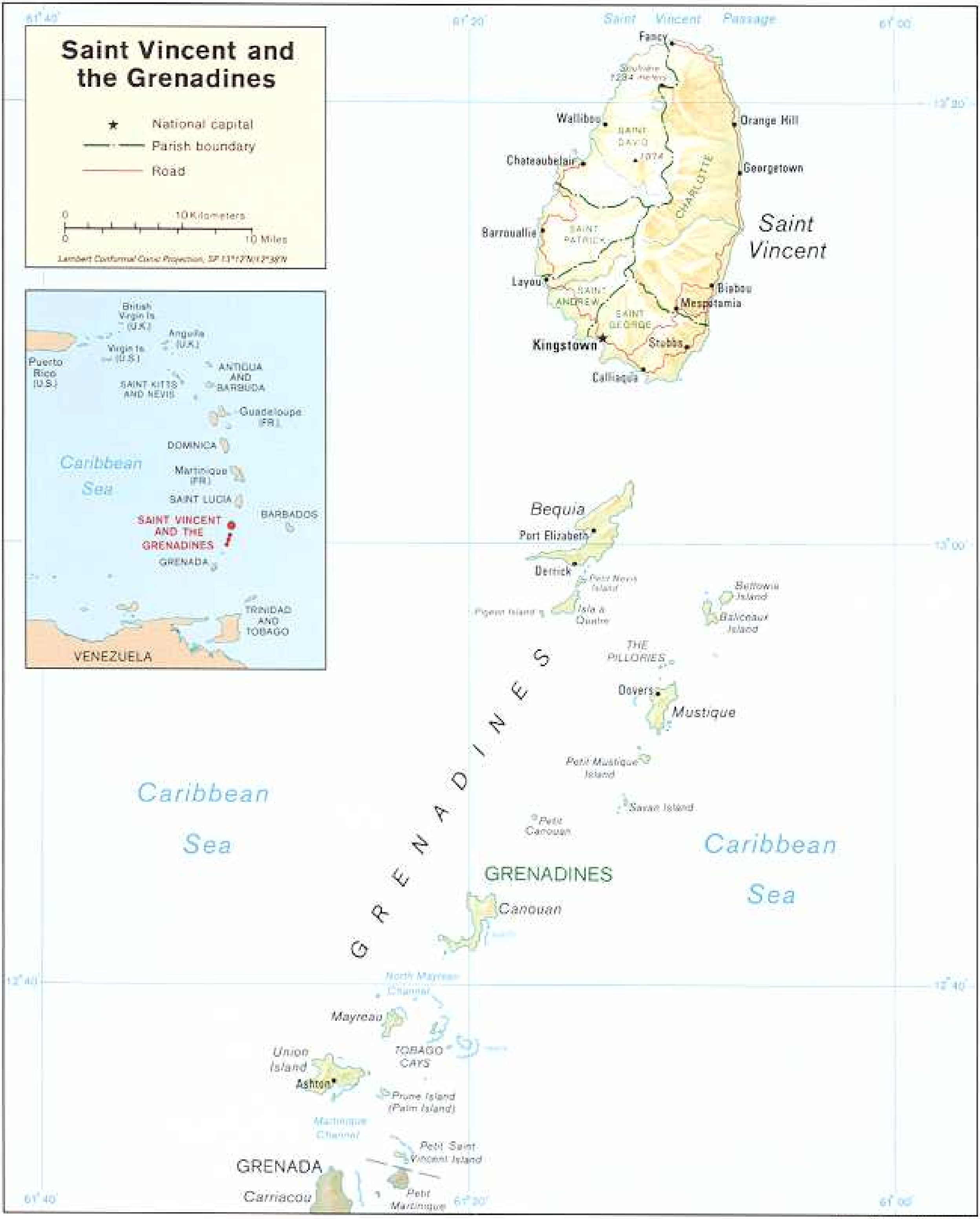
Lambert Conformal Projection
Standard parallels 17°20' and 22°40'
Scale 1:1,450,000

Road
Airport



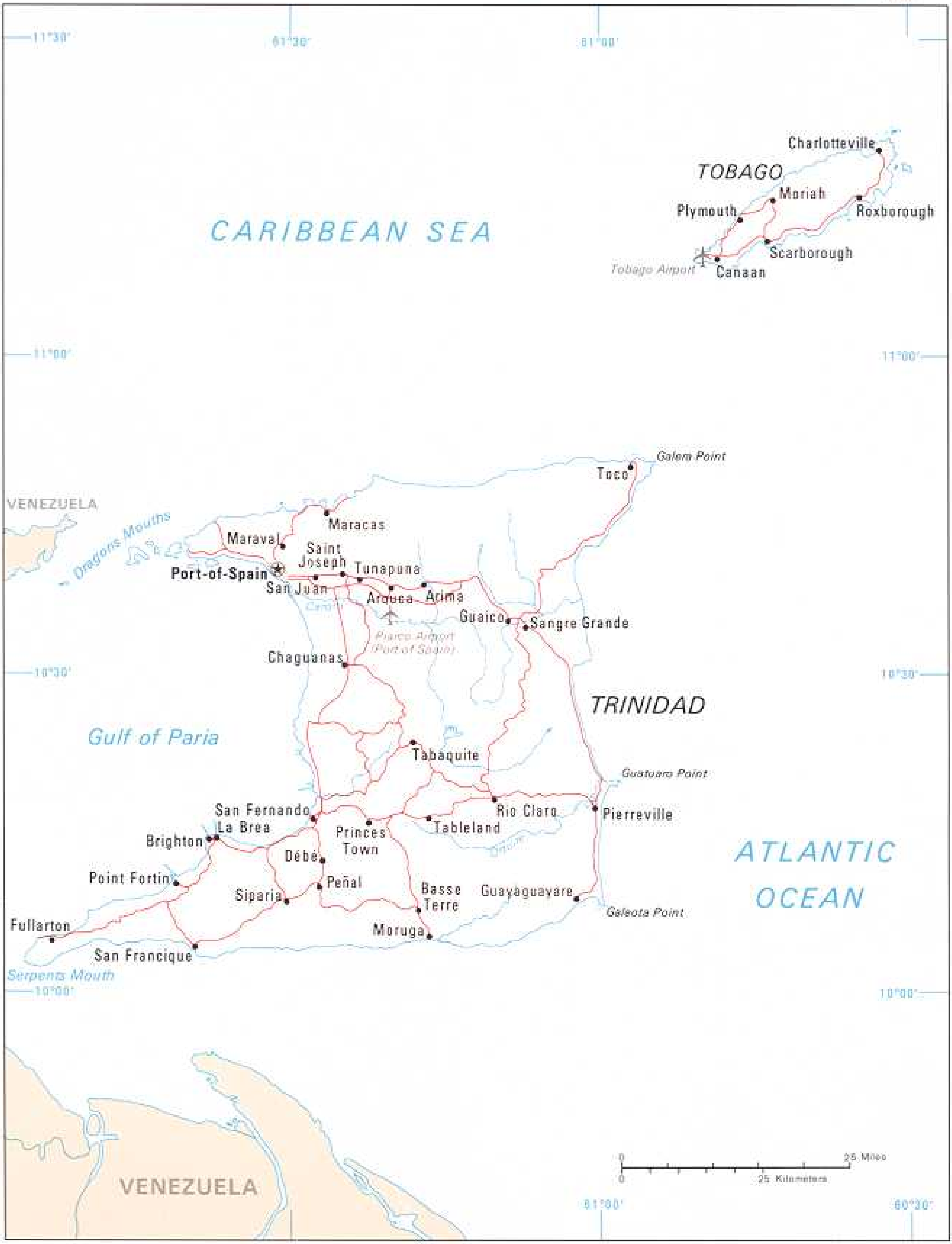
Base 802461 (R03732) 3-96

Base 801673 (546468) 1-91



Base 802429 (545180) 1-96

Trinidad and Tobago

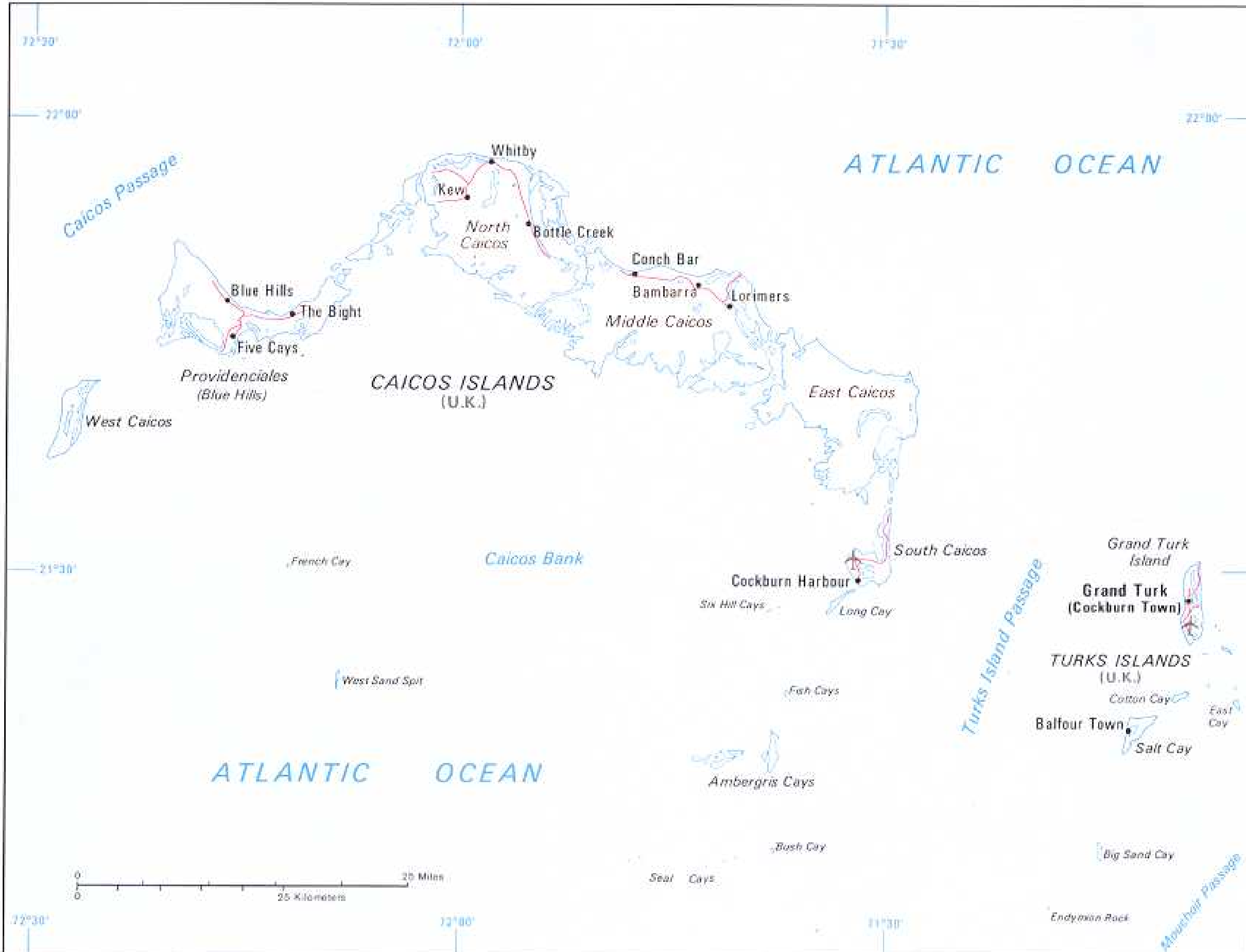


502486 1-76 (541680)
Lambert Conformal Projection
Standard parallels 9°20' and 14°40'
Scale 1:1,000,000

Road

Airport

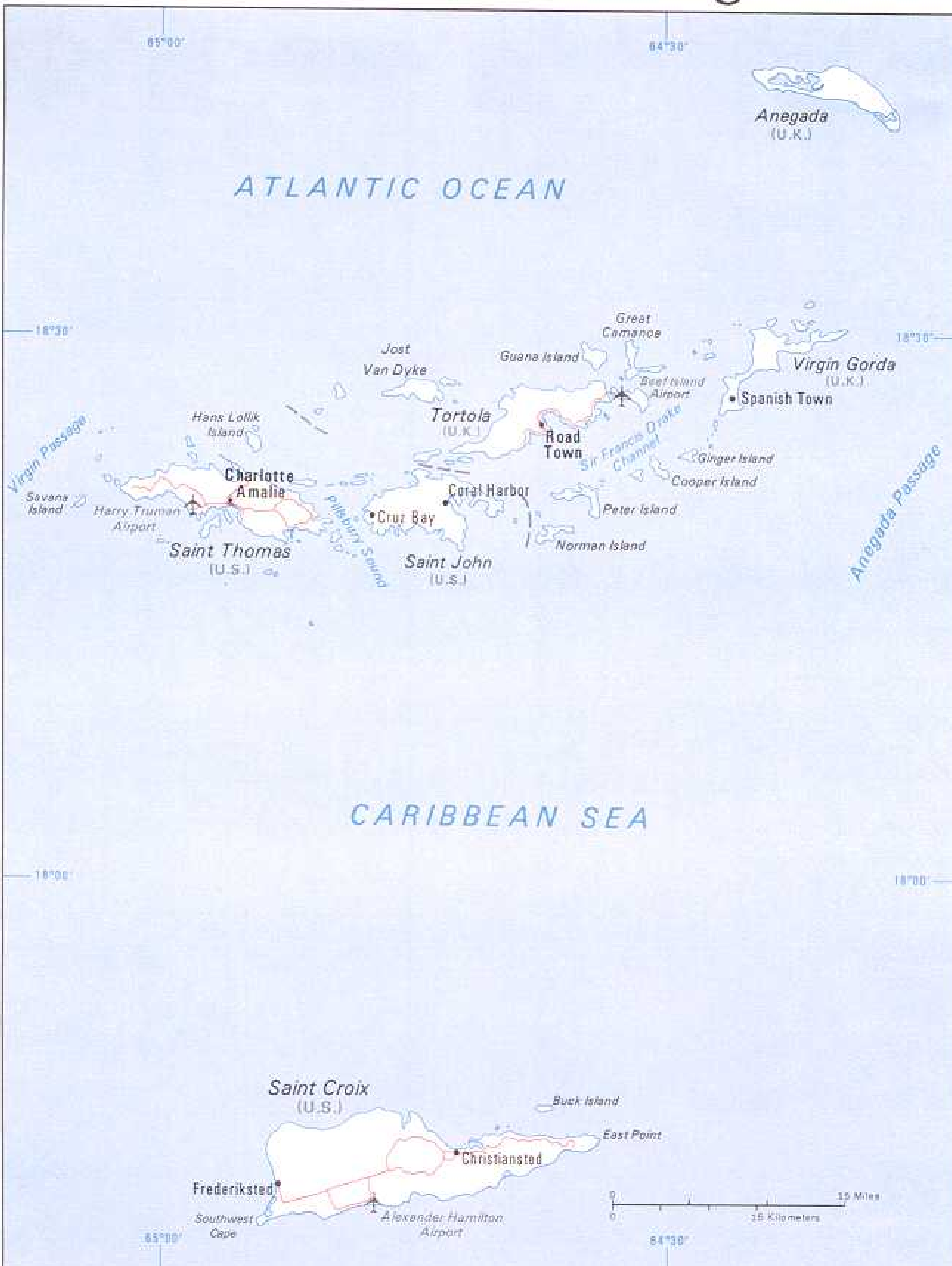
Turks and Caicos Islands



502495 1-76 (541657)
Transverse Mercator Projection
Scale 1:700,000

Road
Airport

Virgin Islands



502618 1-76 (543648)
Lambert Conformal Projection
Standard parallels 17°20' and 22°40'
Scale 1:800,000

Road
Airport
Line of
Separation
(not a formal territorial
boundary or territorial limit)

IV. COUNTRY PROFILES.

A. Anguilla.

1. Geography. Anguilla has a total land area of 91 sq km, about one-half the size of Washington, DC, and is a territory of the United Kingdom. It consists of a small group of flat, low-lying islands located at the northern end of the Leeward Islands of the Lesser Antilles, 235 km east of Puerto Rico. The islands are mainly coral and limestone with some scrub oak, a few other trees, and some commercial salt ponds. The largest island is Anguilla, which has the country's highest elevation, 65 m at Crocus Hill. Major industries are tourism, offshore banking, lobster fishing and boat building. The country has 279 km of roads, 253 km of which are paved, and three airports, only one of which has paved runways.

2. Climate. The climate of Anguilla is tropical, with heat and humidity moderated by northeast trade winds. Daily or seasonal temperature variations are small. The islands are in the path of frequent hurricanes and tropical storms from July through November.

3. Population and Culture. As of July 2000, the population of Anguilla was estimated to be 11,797 persons, nearly 130 per sq km. Nearly all Anguillans are black, 95% are literate, and the average life expectancy at birth is just over 76 years. Religious preferences include: 40% Anglican, 33% Methodist, 7% Seventh Day Adventist, 5% Baptist, 3% Roman Catholic, and 12% other religions.

4. Sanitation and Living Conditions. The average standard of living for Anguillans is relatively good, due to an expanding economy, modern communications, and good medical care. Although medical care is available throughout the country, the standard of care is lower than that of most industrialized countries. Potable water is sometimes scarce due to distribution problems. Several serious food-borne and water-borne diseases, including hepatitis A, are common. Ciguatera poisoning, caused by eating fish that contain a toxin, is common. The toxin is not destroyed by cooking. Raw sewage frequently contaminates coastal waters and causes beach closings.

B. Antigua and Barbuda.

1. Geography. Antigua and Barbuda have a total land area of 442 sq km, about 2.5 times the size of Washington, DC, and lie in the northern half of the Leeward Islands of the Lesser Antilles between the Caribbean Sea and the Atlantic Ocean. The country includes the islands of Antigua and Barbuda, plus a remote uninhabited rock island, Redondo (which has its own king). These are mainly low-lying, dry, limestone and coral islands, with some higher volcanic areas. The economy is primarily based on tourism, offshore finance and banking, construction, and agriculture mainly for domestic consumption. The country's highest elevation is 402 m at Boggy Peak, near the southwestern corner of Antigua Island. Land use includes: 18% arable, 9% permanent pasture, 11% forests and woodlands, and 62% other (e.g., paved areas, buildings, etc.). Electricity is produced exclusively by generators powered by fossil fuels. Water management, adequate supply of potable water, and sewage disposal are frequent problems, as are periodic droughts and deforestation. Roughly 3,000 refugees fleeing the 1995 volcanic eruption on Montserrat have settled in Antigua and Barbuda and have strained the country's resources. The population is a mixture of ethnicities, cultures, and religious preferences. The country has about 77 km of railroads, 250 km of roads, most of which are paved, and three airports, two of which have paved runways.

2. Climate. The climate is tropical marine, with little seasonal variation in temperature, but is dry because of the constant trade winds. The average combined rainfall is 114 cm per year, falling mostly during the rainy season, September through November. Average temperatures vary from 23°C to 29°C, being coolest from November to May. Hurricanes and tropical storms are an annual threat to these islands from July to October.

3. Population and Culture. The population of Antigua and Barbuda was estimated in July 2000 to be 66,422 persons, slightly more than 150 persons per sq km. The people are a mixture of nationalities, including African, British, Portuguese, Lebanese and Syrian. Most of the population is descended from Africans brought here as slaves during the 16th to 19th centuries. The literacy rate is 89%, and the average life expectancy at birth is about 70.5 years. The population is approximately 36% urbanized. The extended family is important. Religious preferences include mostly Anglican or other Protestants and some Roman Catholics.

4. Sanitation and Living Conditions. The standard of living for most Antiguans is relatively good, as a result of an expanding economy ranked among the upper 50% in the world, and modern communications and transportation systems. Medical care is available throughout the country, but it is lower than in most industrialized countries. Potable water is sometimes scarce, due to distribution problems. Some serious food-borne and water-borne diseases, including hepatitus A, are common. Ciguatera poisoning is caused fairly often by eating reef fish that contain a toxin, and the risk is not reduced by cooking the fish. Roads are narrow and not well-maintained. Traffic accidents are common due to limited police enforcement of traffic regulations, poor road conditions, and the fact that vehicles drive on the left side of the road. Raw sewage from hotels and yachts has contaminated coastal waters enough to pose a health risk and close beaches for recreational use.

C. Aruba.

1. Geography. Aruba has a total land area of 193 sq km, slightly larger than Washington, DC. It is a flat island, with a few hills, sparse vegetation and white sandy beaches, located 25 km off the coast of Venezuela in the Caribbean Sea. It is part of the Kingdom of the Netherlands, formerly included in the Netherlands Antilles. The country's highest point is 188 m at Mount Jamanota. Land use includes 7% aloe plantations and 93% other uses. Major industries are tourism, offshore financial services, oil refining and transshipment, lobster fishing, and boat building. Aruba's economy is among the top 25% in the world. The country has 800 km of roads, 513 km of which are paved, and two airports, both with paved runways. Road conditions and maintenance are generally good. Medical care is available but is not up to Western standards. All electricity is produced from fossil fuel. Aruba is seldom affected by hurricanes or tropical storms, which usually pass north of the island. Limited rainfall often leads to dusty conditions over most of the island. Palm Beach, stretching for 10 km along the west side of the island, has been called the Turquoise Coast and is a major beach resort area.

2. Climate. Aruba's climate is tropical, moderated by constant trade winds from the Atlantic. It lies outside the usual Caribbean hurricane belt. Temperatures do not vary much daily or seasonally. It is seldom higher than 32°C during the day or lower than 24°C at night. Rainfall averages only about 56 cm per year.

3. Population and Culture. The population of Aruba was estimated in July 2000 to be 69,539 persons, or slightly more than 360 persons per sq km, and is 80% mixed white and Carib Amerindian and 20% other origins. Religious preferences are 82% Roman Catholic, 8% protestant, and 10% others, including Hindus, Muslims, Confucianists, and Jews. The literacy rate is 97%, and the average life expectancy at birth is about 78.4 years. The bulk of the population is employed in tourism-related industries, offshore financial services, or oil refining.

4. Sanitation and Living Conditions. The standard of living for most Arubans is good, with an economy ranked among the top 25% in the world, and modern communications and transportation systems. Medical care is available throughout the country and potable water is generally available. Some serious food-borne and water-borne diseases, including hepatitis A, are common in addition to periodic outbreaks of ciguatera poisoning. Roads are not clearly marked but are maintained fairly well. Traffic safety is a concern, and police enforcement is lax.

D. The Bahamas.

1. Geography. The Bahamas is a chain of about 700 islands and 2,400 cays (low islands or reefs of sand or coral, 30 of which are inhabited) in the Atlantic Ocean, about 320 km southeast of Florida. This British Commonwealth country has a total land area of 10,070 sq km, slightly smaller than Connecticut. The islands are mainly low, flat coral formations, with some low rounded hills. The highest point in the country is 63 m at Mount Alvernia on Cat Island. Land use is 1% arable, 32% forests and woodlands, and 67% other. Natural resources include salt, argonite, and timber. The Bahamas is a developed nation in the top 25% of the world's economies. Tourist facilities are widely available. Private medical care is available in Nassau and Freeport, but it is not up to the standards of most industrialized countries. Medical care is substandard outside Freeport and Nassau. The two main industries are tourism and offshore financial services. All electricity is produced from fossil fuel. The country has 2,693 km of roads, of which 1,546 are paved, and 62 airports, 33 of which have paved runways. Road maintenance and travel are limited except for areas in or near Freeport or Nassau. The Bahamas, as a flag-of-convenience registry nation, has one of the largest registered merchant marine fleets in the world, including 1,075 ships from 49 countries. Hurricanes and other tropical storms frequently cause extensive flood and wind damage from June through November. Destruction of coral reefs and solid waste disposal are major environmental concerns. The Bahamas is strategically located near the U.S. and Cuba. Drug traffic to the U.S. and Europe and related money laundering have been major criminal concerns in the Bahamas since the 1980s.

2. Climate. The climate of the Bahamas is tropical marine, moderated by the warm waters of the Gulf Stream. Daytime temperatures typically range between 15°C and 24°C, and winters are mild. Hurricanes and other tropical storms can cause extensive flood and wind damage from June through November.

Nassau (elevation 4 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	25	25	26	27	29	31	31	32	31	29	27	26
MINIMUM	18	18	19	21	22	23	24	24	24	23	21	19

Monthly Precipitation (liquid equivalent)

MEAN (mm)	36	38	36	64	117	163	147	135	175	165	71	33

3. Population and Culture. The population of The Bahamas was estimated in July 2000 to be 294,982 persons, or about 29.3 persons per sq km. The population is 85% blacks, 12% whites, and 3% others (mainly Asians and Hispanics). Religious preferences are: 32% Baptist, 20% Anglican, 19% Roman Catholic, 6% Methodist, 6% Church of God, 12% other Protestant, 3% profess no religion, and 2% other. The literacy rate is 98.2%; the average life expectancy at birth is about 71 years, and the country is about 85% urbanized.

4. Sanitation and Living Conditions. Native Bahamians have a good standard of living with an economy in the top 25% of the world, including adequate medical care except on outlying islands. Potable water and sewage treatment are available in Freeport and Nassau, where most of the population is concentrated. Food-borne and water-borne diseases, including hepatitis A, are commonly acquired through unsanitary food handling procedures and contaminated water. Ciguatera poisoning is fairly common and results from eating reef fish such as grouper, snapper, amberjack, or barracuda during massive algae blooms known as red tides.

E. Barbados.

1. Geography. Barbados has a total land area of 430 sq km, about 2.5 times the size of Washington, DC. This country lies northeast of Trinidad and Tobago and is the farthest east of the Windward Islands of the Lesser Antilles. It is primarily a flat, low-lying coral island that rises gently to a central highland region. The economy is based primarily on tourism, sugar cane and light manufacturing. The country's highest point is 336 m at Mount Hillaby in the north-central part of the island. Land use includes: 37% arable, 5% permanent pasture, 12% forests and woodlands, and 49% other (e.g., covered by paved areas, buildings, etc.). The country's most important natural resources are petroleum, fish, and natural gas. Electricity is produced exclusively by generators powered by fossil fuels. Pollution of coastal waters by waste from ships, soil erosion, and sewage and solid waste disposal are frequent problems. There are periodic landslides and infrequent hurricanes. The population is a mixture of ethnic origins, cultures, and religious preferences. About 75% of the labor force is employed in services and tourism. The country has no railroads but has 1,600 km of roads, 1,578 km of which are paved, and one airport with paved runways.

2. Climate. The climate is tropical, with a rainy season from June through October. It is generally sunnier and drier than more mountainous nearby islands. The annual combined rainfall is 128 cm, most falling in the rainy season. Average daily temperatures vary from 21°C to 31°C, with the coolest weather occurring from January to March. Hurricanes and tropical storms may threaten Barbados from June through November.

Bridgetown, Barbados (elevation 55 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	28	28	29	30	31	31	30	31	31	30	29	28
MINIMUM	21	21	21	22	23	23	23	23	23	23	23	22

Monthly Precipitation (liquid equivalent)

MEAN (mm)	66	28	33	36	58	112	147	147	170	178	206	97

3. Population and Culture. The population (sometimes called Barbadians, or Bajans) of Barbados was estimated in July 2000 to be 274,540 persons, or slightly more than 638 persons per sq km. The population is 85% black, 4% white, and 16% other. The literacy rate is 97.4%, and the average life expectancy at birth is about 73 years. The population is approximately 46% urbanized. Religious preferences include: 67% Protestant, 4% Roman Catholic, 17% with no professed religion, and 12% other religious affiliations. Sources of employment include: 75% service and tourism, 15% light industry (e.g., electronics components), and 10% agriculture (mainly sugarcane). Offshore finance and business services are growing in importance. Unemployment is about 12%.

4. Sanitation and Living Conditions. The standard of living for most Barbadians is relatively good due to an expanding economy ranked among the upper 50% in the world. Good communications and transportation systems are present. Adequate medical care is available throughout the country. Potable water is sometimes scarce due to sewage and solid waste disposal problems. Serious food-borne and water-borne diseases, including hepatitis A and typhoid fever, occasionally occur. Roads are narrow and have no shoulders, and road maintenance is only fair. Marine hazards in coastal waters include jellyfish, sharks and sea urchins. Raw sewage and petroleum spills from ships and yachts have polluted the surrounding reefs and threaten populations of flying fish, the main fish stock of Barbados.

F. British Virgin Islands.

1. Geography. The British Virgin Islands comprise 40 islands, of which 15 are inhabited, and have a total land area of 150 sq km (about 0.9 times the size of Washington, DC). These islands lie at the eastern end of the Greater Antilles, between the Caribbean Sea and the Atlantic Ocean, and include the island of Anegada. Topographically, they range from low-lying coral to steep and hilly volcanic islands. The economy is based primarily on tourism, offshore business registrations, and agriculture (mainly livestock). The country's highest point is 521 m at Mount Sage. Land use includes: 20% arable, 7% permanent crops, 33% permanent pasture, 7% forests and woodlands, and 33% other (e.g., covered by paved areas, buildings, etc.). Electricity is produced exclusively by generators powered by fossil fuels. The country has about 113 km of roads and three airports, two with paved runways. The British Virgin Islands have strong ties to the U.S. Virgin Islands a few km to the southwest.

2. Climate. The climate is subtropical and humid. Temperatures are moderated by trade winds but vary only slightly throughout the year. Average daily temperatures are 29°C in summer and 27°C in winter, with a drop in temperature of about 4°C every evening. Average rainfall throughout the islands is 102 cm per year, most of it falling during the rainy season from May through November, although droughts are common. Hurricanes and tropical storms frequently strike these islands from July though November, causing serious damage and loss of life.

3. Population and Culture. The population was estimated in July 2000 to be 19,615 persons, or slightly fewer than 131 persons per sq km. Ethnically, the population is about 90% black and 10% white and Asians. The literacy rate is 97.8%, and the average life expectancy at birth is about 75 years. Religious preferences include: 86% Protestants, 6% Roman Catholics, 2% with no stated preference, and 6% other. The bulk of the workforce is employed in tourism-related or offshore business and financial service jobs. Unemployment is only 3%.

4. Sanitation and Living Conditions. The standard of living for most natives is relatively good due to an expanding and prosperous economy in the Caribbean and ready availability of modern communication and transportation systems. Adequate medical care is available throughout the country. There are a few seasonal wells and streams on the island of Tortola. Potable water is often scarce, and there is heavy dependence on wells and rainwater catchments. Sewage disposal is a problem, and serious food-borne and water-borne diseases, including hepatitis A and typhoid fever, occur. Many roads are steep, narrow, winding and poorly maintained.

G. Cayman Islands.

1. Geography. The Cayman Islands are the largest British territory in the Caribbean. They have a total land area of 259 sq km, about 1.5 times the size of Washington, DC. These islands lie about 304 km northwest of Jamaica, 768 km south of Florida, and nearly half-way between Cuba and Honduras. They have a low-lying limestone foundation surrounded by coral reefs. The economy is based primarily on tourism, offshore financial services and construction. Roughly 70% of the country's gross domestic product comes from tourism. The economy is among the top 25% in the world. Good medical care is available. The country's highest point is 43 m at the Bluff. Land use includes: 8% permanent pasture, 23% forests and woodlands, and 69% other (e.g., covered by roads, houses, recreational facilities, etc.). Electricity is produced exclusively by generators powered by fossil fuels. There is no natural source of fresh water except rainwater catchment. About 90% of food and consumer goods must be imported. Natural resources include fish and a climate and beaches that foster tourism. The country has about 406 km of roads, of which 304 km are paved, and two airports, one with paved runways. The Cayman Islands are strategically located between Cuba and Central America.

2. Climate. The climate is tropical marine, with rainy summers (May through October) and cool, relatively dry winters (November through April). Temperatures are moderated by northeast trade winds and vary only slightly seasonally. Average daily temperatures range between 26ºC and 29ºC in summer and 24ºC to 26ºC in winter. Average combined rainfall is 102 cm per year, falling primarily in the rainy season, May through November. Hurricanes and tropical storms threaten the islands from July to November.

3. Population and Culture. The population of the Cayman Islands was estimated in July 2000 to be 34,763 persons, or slightly more than 134 persons per sq km. Ethnically, the population is 40% mixed, 20% black, 20% Caucasian, and 20% expatriates of various groups. The literacy rate is 98%, and the average life expectancy at birth is nearly 79 years. Most people are either Protestants or Roman Catholics.

4. Sanitation and Living Conditions. The Cayman Islanders enjoy one of the highest standards of living in the world. Modern communications systems, transportation, and electronic devices are all readily available. Potable water is only available by rain catchment or importation. Serious food-borne or water-borne diseases, including hepatitis A and typhoid fever, occasionally occur. Most public transportation and roads are in good condition and are well-maintained.

H. Cuba.

1. Geography. Cuba is the largest island in the Caribbean Sea (about 1,250 km long from northwest to southeast) and includes several small offshore islands, the largest of which is the Isla de la Juventud (Isle of Youth). Cuba has a total land area of 110,860 sq km, slightly smaller than Pennsylvania. Cuba occupies the northern boundary of the Caribbean Sea, 144 km south of Key West, Florida. Its topography is mainly flat or rolling plains, with rugged hills and mountains in the southeast. There are three distinct mountain systems: 1) the western (occidental), 2) central, and 3) eastern (oriental). The oriental geography is the most extensive and complex and includes the highest point, Pico Turquino, at 2,005 m. The small central mountain system consists of a number of low mountain ranges and hills. The occidental system is a region of rugged mountains and hills with irregular limestone topography characterized by fissures, sinkholes, underground streams and caverns. The remaining 75% of the island's surface consists of extensive plains and basins primarily supporting sugarcane and livestock. The Cauto River in the east is the country's longest (370 km) and principal inland waterway. The northern coastline is steep and rocky. The southern coast lowlands contain extensive mangrove swamps, except in the more mountainous east.

Guantanamo U.S. Naval Base, on Cuba's southeastern tip, is leased to the U.S. and shares a 29 km land border with the main island of Cuba. Cuba is a developing country, and its economy ranks in the lower half of world's economies. Since the end of large subsidies from the former Soviet Union, Cuba's economy has been primarily based on sugar, petroleum, food, tobacco, and textiles. Land use includes: 24% arable, 7% permanent crops, 27% permanent pasture, 24% forests and woodlands, and 18% other. The country's most important natural resources are cobalt, nickel, iron ore, copper, manganese, salt, timber, and petroleum. Electricity is produced primarily by fossil fuel-powered generators (89.52%). Environmental concerns include: pollution of streams and shores by petroleum spills, industrial wastes and agro-chemicals, overhunting of threatened wildlife populations, and deforestation.

Inadequate water and sewage treatment are frequent problems. Cuba has 240 km of waterways, 4,807 km of railroads, 60,858 km of roads (29,820 km of which are paved) and 170 airports, 77 with paved runways.

2. Climate. Cuba is located entirely within the tropical zone, but cool prevailing trade winds and the warm Gulf Stream combine to produce a temperate, semi-tropical climate. The island lies in the path of tropical hurricanes that occur every one to two years, usually during June through November. Tropical downpours during rainy seasons often wash out roads, and mudslides are frequent in less developed parts of the country. In September 1998, the eye of Hurricane Georges (which passed north of neighboring Port-au-Prince, Haiti) damaged aqueducts and sewers in Cuba. Cuba's rainy season occurs from May to October, and a dry season prevails from November to April. The island-wide rainfall is about 137 cm per year but varies with elevation and location; droughts are common. Average daily temperatures vary from 22°C in winter to 28°C in summer.

Havana (elevation 24 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	26	26	27	29	30	31	32	32	31	29	27	26
MINIMUM	18	18	19	21	22	23	24	24	24	23	21	19

Monthly Precipitation (liquid equivalent)

MEAN (mm)	71	46	46	58	119	165	125	135	150	173	79	58

3. Population and Culture. The population of Cuba was estimated in July 2000 to be 11,141,997 persons, or slightly more than 100 persons per sq km. The population's ethnic makeup is 51% mulatto, 37% white, 11% black and 1% Chinese. The literacy rate is 95.7%, and the average life expectancy at birth is about 76 years. The population is approximately 75% urbanized. Religious preferences (based on figures before Castro assumed power) included: 85% Roman Catholic, plus various Protestant sects, Jews, and Santeria. The workforce is employed mainly in light industries, agriculture and service jobs.

4. Sanitation and Living Conditions. Health care for most Cubans is relatively good, and the standard of living is slowly improving due to an expanding economy and increased commerce with other countries, despite the continuing U.S. economic embargo. Medical care is available throughout the country but is below Western standards. Drinking water is often contaminated due to power outages, equipment maintenance problems, cross contamination from leaking pipes, and improper disposal of sewage and solid waste. Food-borne and water-borne diseases, including typhoid fever, are common. Ciguatera poisoning caused by eating contaminated fish occurs in Cuba and throughout the Caribbean. Roads and their maintenance are only fair to good. Raw sewage and petroleum spills from ships, untreated industrial wastes, and agro-chemical run-off frequently contaminate many streams, coastal waters and drinking water sources.

I. Dominica.

1. Geography. Dominica has a total land area of 754 sq km and is about four times the size of Washington, DC. It lies nearly half way between Puerto Rico and Trinidad and Tobago, in the northern part of the Windward Islands of the Lesser Antilles. Dominica is characterized by rugged mountains of volcanic origin and is the most mountainous of the Lesser Antilles. The economy is primarily based on agriculture and is highly vulnerable to climatic events, especially tropical storms. Agriculture, primarily bananas, accounts for 21% of the country's gross domestic product, 50% of exported commodities, and 40% of the workforce. Other industries include soap, coconut oil, tourism, copra, furniture, cement blocks, and shoes. Dominica's economy is still developing, but it already ranks among the upper half of the world's economies. Further development of tourism is difficult because of the rugged coastline, absence of beaches, and inadequate airport facilities. Heavy rainfall makes flash floods a constant threat, and destructive hurricanes can be expected during late summer months. The country's highest point is 1,447 m at Morne Diablatins, nearly in the middle of the northern half of the island. Land use includes: 9% arable, 13% permanent crops, 3% permanent pasture, 67% forests and woodlands, and 8% other. Half the country's electricity is produced by generators powered by fossil fuels, and the other half is produced by hydroelectric generators. Natural resources include timber, hydroelectric power potential, and arable land. Dominica also has lush national parks, rare indigenous birds, and hot springs and sulfur pools that may draw ecotourists once airport access and roads are improved. The country has about 780 km of roads, 393 km of which are paved, and two airports, both with paved runways, though they can accommodate only small propeller planes. Dominica has been a transshipment point for illegal drugs bound for the U.S. and Europe, and its banking industry has been involved in money laundering.

2. Climate. The climate is tropical. Heavy rainfall is common, and destructive hurricanes can be expected during late summer from July to November. Temperatures are moderated by trade winds but vary only slightly throughout the year. Average daily temperatures are seldom above 30°C in summer and seldom below 18°C in winter. Average rainfall is 208 cm per year, falling primarily during the rainy season, May through November.

Roseau, Dominica (elevation 18 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	29	29	31	31	32	32	32	32	32	32	31	30
MINIMUM	20	19	20	21	22	23	22	23	23	22	22	21

Monthly Precipitation (liquid equivalent)

MEAN (mm)	132	74	74	61	97	196	274	262	226	198	224	163

3. Population and Culture. The population of Dominica was estimated in July 2000 to be 71,540 persons, or more than 94 persons per sq km. Ethnically, the population is black and Carib Amerindian. Most people are descended from Africans brought to work the banana plantations. The literacy rate is 94%, and the average life expectancy at birth is about 73 years. Religious preferences include: 77% Roman Catholic, 15% Protestant, 2% with no stated preference, and 6% other. The population is about 57% urbanized.

4. Sanitation and Living Conditions. The standard of living for most Dominicans is relatively good due to an expanding, prosperous economy, although unemployment is high and may reach 20%. Limitations on travel and transportation, due to inadequate roads, rugged terrain and flash flooding, make it difficult for people in more remote areas to get access to modern materials, conveniences, and medical care. Food-borne and water-borne diseases are common. Many roads are steep, narrow, winding, and not well maintained. Roads are often wet, and there are few guardrails to protect drivers from deep ravines. Traffic drives on the left side of the road, which poses an extra danger for persons who learned to drive in the U.S.

J. Dominican Republic.

1. Geography. The Dominican Republic occupies the eastern 65% of the island of Hispaniola, which is the second largest island in the Greater Antilles. It is located 965 km southeast of Florida between Cuba and Puerto Rico. This country's total land area of 48,380 sq km is slightly more than twice the size of New Hampshire. It shares a 275 km western land border with Haiti and has 1,288 km of shoreline, roughly half on the Caribbean Sea and half on the Atlantic Ocean. The highest point is Pico Duarte (3,175 m), located near the middle of the western third of the country. The lowest point is Lago Enriquillo (-46 m), in the far southwest near the border with Haiti. These two spots are also the highest and lowest points on any of the Caribbean islands. The Dominican Republic consists of rugged highlands and mountains interspersed with fertile valleys. There are numerous coastal beaches suitable for development. The economy is dependent on tourism, sugar processing, ferronickel and gold mining, textiles, cement, and tobacco. Land use includes: 21% arable (about 2,300 sq km are irrigated), 9% permanent crops, 43% permanent pasture, 12% forests and woodlands, and 15% other. The country's most important natural resources are nickel, bauxite, gold, and silver. Electricity is produced by generators powered by fossil fuels (72.04%), hydroelectric generators (27.62%), and other methods such as wind or solar cells (0.34%). The country has 757 km of railroads used mainly to transport sugarcane or ore. It has 12,600 km of roads, 6,224 km of which are paved, and 28 airports, 13 with paved runways.

2. Climate. The Dominican Republic's climate is tropical maritime, with little annual change in temperature but with pronounced seasonal variations in rainfall. The nearly constant northeastern trade winds that blow throughout the year help moderate the tropical heat and humidity. The average rainfall is about 142 cm per year, falling mostly in the rainy season (May through November). The northern side of the island receives nearly twice as much rain as the southern side and is wetter throughout the year. Water shortages, droughts and flooding can be locally severe. Average daily temperatures in the lowlands vary only a few degrees from 25°C, but higher elevations get much cooler. The island of Hispaniola is located in the northern half of the Caribbean hurricane belt. Hurricanes and tropical storms, which may occur between June and November, frequently cause severe damage and loss of life.

Santo Domingo, Dominican Republic (elevation 17 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	29	29	29	29	30	31	31	31	31	31	30	29
MINIMUM	19	19	19	21	22	22	22	23	22	22	21	19

Monthly Precipitation (liquid equivalent)

MEAN (mm)	61	32	48	99	173	157	163	160	185	152	122	61

3. Population and Culture. The population of the Dominican Republic was estimated in July 2000 to be 8,442,533 persons, or slightly more than 174 persons per sq km. Ethnically, the population is 73% mixed, 16% white, and 11% black. The literacy rate is 82.1%, and the average life expectancy at birth is about 73 years. The population is approximately 62% urbanized. Religious preferences include 95% Roman Catholic and 5% other. Major sources of employment include: 58.7% in government services and tourism, 24.3% in industry, and 17% in agriculture (mainly sugarcane).

4. Sanitation and Living Conditions. The standard of living for most upper-income and middle-class professionals is relatively good. Most of the small farmers are extremely poor. The economy is expanding but is still ranked among the lower 50% in the world. Medical care is substandard throughout the country. Most water and sewage treatment systems are inadequate, poorly maintained, and poorly supplied with treatment materials and repair parts. Drinking water supplies and food are often contaminated by raw sewage or industrial waste. Food-borne and water-borne diseases, including hepatitis A, typhoid fever, and several enteric bacterial diseases, are common. Tuberculosis is prevalent throughout the country. Ciguatera poisoning frequently occurs. Many roads are narrow and winding, especially in the mountains, and road maintenance is inadequate. Soil erosion has killed large areas of coral beds near the shore, and deforestation is a growing problem. Pollution of coastal waters and beaches by petroleum spills and wastes from ships and yachts are serious environmental problems.

K. Grenada.

1. Geography. The country of Grenada includes the islands of Grenada, Carriacou, and Petite Martinique, in addition to a small group islands that are not inhabited. Grenada has a total land area of 340 sq km, about twice the size of Washington, DC. It lies 145 km north of Trinidad and Tobago, at the southern end of the Windward Islands in the Lesser Antilles, between the Caribbean Sea and the Atlantic Ocean. Grenada is the smallest independent country in the Western Hemisphere, and the island proper is volcanic with central mountains. The country's highest point is 840 m at Mount Saint Catherine, a few km northeast of the center of the island of Grenada. Land use includes: 15% arable, 18% permanent crops, 3% permanent pasture, 9% forests and woodlands, and 55% other. The country's most important natural resources are timber, tropical fruit, and deepwater harbors. The economy is based primarily on tourism, construction, bananas, and light manufacturing. Offshore financial services are increasing in importance. Grenada is the world's second largest producer of nutmeg and usually supplies nearly 25% of the total annual demand. All the country's electricity is produced by generators that run on fossil fuel. About 62% of the labor force is employed in services that directly or indirectly support tourism, which provides over 75% of Grenada's annual gross domestic product. The country has 1,040 km of roads, 638 km of which are paved, and three airports, all with paved runways. Vehicles drive on the left side of the road. Grenada shares the administration of the Grenadines Islands with Saint Vincent and the Grenadines. For a number of years, Grenada has been the site of one campus of the multinational St. George's Medical School. Usually, a significant portion of that school's students are U.S. citizens.

2. Climate. Grenada's climate is tropical, tempered by northeast trade winds. Average daily temperatures vary slightly from 27°C, with a dry season from January through May and a rainy season from June through December. Total rainfall during the rainy season averages about 150 cm per year on the coast and twice that in the mountains. The island lies on the edge of the hurricane belt and may be hit by tropical storms or hurricanes from June through November.

3. Population and Culture. The population of Grenada was estimated in July 2000 to be 89,018 persons, or slightly fewer than 262 persons per sq km. Ethnically, the population is 82% black and nearly 18% South Asians and Europeans; there are also a few Arawak/Carib Amerindians. Most of the population is descended from Africans brought over to work sugar plantations during the 16th to 19th centuries. The literacy rate is 98%, and the average life expectancy at birth is about 64 years. The population is approximately 37% urbanized. Religious preferences include: 53% Roman Catholic, 13.8% Anglican, and 33.2% other Protestant denominations.

4. Sanitation and Living Conditions. The standard of living for most Grenadians is relatively good. Medical care is available throughout the country, but it is substandard compared to the U.S. Potable water is sometimes scarce, due to local sewage and solid waste disposal problems. Food-borne and water-borne diseases are significant public health problems. Roads are narrow, winding, have no shoulders, and are not well maintained. Ecotourism threatens some key environmental sites, including a small remnant of rain forest.

L. Guadeloupe.

1. Geography. The country of Guadeloupe consists of an archipelago of nine inhabited islands: Basse-Terre, Grande-Terre, Marie-Galante, La Desirade, Îles des Saintes (includes 2 inhabited islands), Saint-Barthelemy, Îles de la Petite Terre, and Saint-Martin (the French part of the island of Saint Martin). It has a total land area of 1,706 sq km, about ten times the size of Washington, DC. Guadeloupe is located at the northern end of the Windward chain of the Lesser Antilles, between the Caribbean Sea and the Atlantic Ocean. Grande-Terre is a low limestone formation; Basse-Terre is volcanic in origin, with interior mountains. Most of the other seven islands are also volcanic. The country's highest point is 1,467 m at Soufriere near the southern end of Basse-Terre. The island of Saint-Martin shares 10.2 km of land border with Saint Maartin (part of the Netherlands Antilles), which divides the Island of Saint Martin approximately on an east-west line. Soufriere is an active volcano, although it has not erupted recently. Land use in Guadeloupe includes: 14% arable (30 sq km are irrigated), 4% permanent crops, 14% permanent pasture, 39% forests and woodlands, and 29% other. The country's most important natural resources are cultivable land, beaches, and a climate that fosters tourism. The economy is primarily based on agriculture, tourism, light industry (mainly sugar and rum production), and government services. Sugar is being replaced by other crops, such as bananas (which now yield about 50% of export earnings), eggplant and flowers. Most manufactured goods, fuel and some food must still be imported. All the country's electricity is produced by generators that run on fossil fuel. The population is mostly black or mulatto, and the vast majority are Roman Catholic. The country has 2,082 km of roads, 1,742 km of which are paved, and they are among the best roads in the eastern Caribbean (some have six lanes). Railroads are limited to privately owned narrow-gauge plantation lines. There are nine airports, eight with paved runways.

2. Climate. Guadeloupe's climate is subtropical, tempered by trade winds, with a rather high humidity. There is a cooler dry season (January through May) and a rainy season (June through November). Total rainfall averages about 150 cm per year and falls mostly during the rainy season. Average daily temperatures vary only a few degrees per day and are around 27°C during the rainy season and 24°C during the dry season. The island is situated in the middle of the hurricane belt, and hurricanes and tropical storms may hit Guadeloupe from June through November, causing severe damage to crops and loss of life.

Camp Jacob, Guadeloupe (elevation 533 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	25	24	25	26	27	27	27	28	28	27	27	26
MINIMUM	18	17	17	18	19	21	20	21	21	20	19	18

Monthly Precipitation (liquid equivalent)

MEAN (mm)	234	155	206	185	292	358	447	389	417	315	312	257

3. Population and Culture. The population of Guadeloupe was estimated in July 2000 to be 426,493 persons, or nearly 250 persons per sq km. Ethnically, the population is 90% black or mulatto, 5% white, and 5% other (including East Indian, Lebanese, and Chinese). The literacy rate is 90%, and the average life expectancy at birth is about 77 years. Religious preferences include: 95% Roman Catholic, 4% Hindu and pagan African, and 1% Protestant. The workforce is employed: 68% in services, 15% in agriculture, and 17% in industry (e.g., construction, rum production). Unemployment is high, especially among young people, and may reach 30%.

4. Sanitation and Living Conditions. The standard of living for most citizens of Guadeloupe is relatively good. The country's economy is growing, but many consumer goods and modern conveniences are not readily available. Roads and transportation are generally very good, but communication systems and many modern electronic consumer goods are inadequate or unavailable. Medical care is available throughout the country, but it is not comparable to that in the U.S. Food-borne and water-borne diseases, such as hepatitis A, enteric bacterial illnesses, and typhoid fever, are common. Ciguatera poisoning is a frequent medical problem.

M. Haiti.

1. Geography. Haiti occupies the western 1/3 of the island of Hispaniola. It is bordered by the Atlantic Ocean to its north and the Caribbean Sea to its south and west. It shares a 275 km land border with the Dominican Republic on its east side. Haiti has a total land area of 27,560 sq km, slightly smaller than Maryland. The country's highest point is Chaine de la Selle (2,680 m) located near Haiti's southeastern corner, about 20 km north of its southern coast and 20 km west of its border with the Dominican Republic. Haiti's topography is mainly rugged and mountainous. It lies mostly in the rain shadow of Hispaniola's central mountains, so it is slightly less humid than most Caribbean nations. Haiti claims Navassa Island as part of its territory.

Political upheaval has been common throughout Haiti's history. Political violence and corruption have periodically caused large numbers of refugees to attempt escape to other countries, especially the U.S. and the Dominican Republic. During the past 20 years, drug trafficking and transshipment through Haiti have greatly increased local crime and strained international relations. There is very high unemployment, and 70% of employed workers do not have formal jobs. Major economic and political reforms are needed to improve living standards in Haiti.

Haiti's economy is primarily based on agriculture, tourism, sugar processing, coffee, minerals, textiles, cement, and light manufacturing. There has recently been some growth in construction and tourism. Land use includes: 20% arable (750 sq km are irrigated), 13% permanent crops, 18% permanent pasture, 5% forests and woodlands, and 44% other. The country's most important natural resources are bauxite, copper, calcium carbonate, gold, marble, and hydro-power. Electricity is produced by generators powered by fossil fuels (55.63%), hydroelectric generators (41.62%), and other methods, such as wind or solar cells (2.75%). The country has 40 km of a privately owned railway, formerly used to transport sugarcane or ore, but this line was closed in 1990. Haiti has 4,160 km of roads, 1,011 km of which are paved, and 13 airports, only 3 of which have paved runways. Some coastal beaches could be suitable for developing additional tourism.

2. Climate. Haiti's climate is tropical and semiarid where mountains in the east cut off trade winds. It has heavy rains and high winds annually from April to June and from August to October, with an average total rainfall of about 135 cm per year. Daily temperatures average 27°C in coastal areas and 19°C in highland areas. It is in the middle of the hurricane belt and is subject to severe storms from June through November, as well as occasional floods and droughts. Earthquakes also occasionally occur.

Port-au-Prince, Haiti (elevation 37 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	31	31	32	32	32	33	34	34	33	32	31	31
MINIMUM	20	20	21	22	22	23	23	23	23	22	22	21

Monthly Precipitation (liquid equivalent)

MEAN (mm)	33	58	86	160	231	102	74	145	175	170	86	33

3. Population and Culture. The population of Haiti was estimated in July 2000 to be 6,867,995 persons, or slightly more than 249 persons per sq km. The population is 95% black and 5% mulatto or white. The literacy rate is 45%, and average life expectancy at birth is about 49 years. The population is approximately 30% urbanized. Religious preferences include: 80% Roman Catholic, 16% Protestant (several denominations), 1% no religious preference, and 3% other. Roughly 50% of the population also practices voodoo. Nearly 70% of the people depend on small-scale subsistence farming for all of their needs.

4. Sanitation and Living Conditions. There are stark differences in living standards between the wealthy upper class and most of the rest of the population. The rich have luxuries, conveniences, and foreign educations for their children. Small farmers are extremely poor. The economy is expanding very slowly and is ranked among the lowest 25% in the world. Haiti is one of the poorest countries in the Western Hemisphere. Most Haitians cannot afford health care. The United Nations has reported that 80% of Haiti's people live in abject poverty and cannot meet their daily needs. Medical care is substandard throughout the country.

There is often a widespread shortage of potable drinking water. Most of the country's water and sewage treatment systems are inadequate, poorly maintained, and poorly supplied with treatment materials and repair parts. Drinking water supplies and food are often contaminated by raw sewage or industrial waste. Incidence of food-borne and water-borne diseases, including hepatitis A, typhoid fever, and enteric bacterial diseases, is the highest in the

Caribbean. Tuberculosis and other infectious diseases are prevalent throughout the country. Ciguatera poisoning is also common.

Travel in most of Haiti can be dangerous because many roads are narrow and winding, especially in the mountains, and road maintenance is only fair. Native drivers tend to be aggressive, and government officials often do not have the equipment needed to clear accidents from roads. Traffic enforcement and emergency response are almost nonexistent outside the capital. Brazen daytime theft of vehicles, boats, or personal property can occur anywhere and anytime. Marine hazards in coastal waters include jellyfish and corals. Raw sewage and petroleum spilled from ships and yachts have polluted beaches and coral beds and caused local fish kills. Soil erosion is severe and deforestation is extensive. Most of the remaining forests are being cleared for agriculture and the wood used as fuel.

N. Jamaica.

1. Geography. Jamaica has a total land area of 10,830 sq km, slightly smaller than Connecticut. It lies in the Caribbean Sea approximately 965 km south of Miami, FL, south of Cuba and west of Hispaniola. It is the third largest island in the Greater Antilles. Jamaica's highest point is Blue Mountain Peak, at 2,256 m, about 25 km northeast of Kingston, near the eastern end of the island. The topography is mostly mountainous with a narrow, discontinuous coastal plain. Jamaica occupies a strategic location between the Cayman Trench and the Jamaica Channel, the main Caribbean sea lanes for the Panama Canal. Jamaica is a developing nation whose economy, ranked in the lower half of the world, is primarily based on bauxite (bauxite and alumina make up over 50% of exports) and tourism. There has recently been some growth in light manufacturing and data processing for U.S. firms. Land use are: 14% arable (350 sq km are irrigated), 6% permanent crops, 24% permanent pasture, 17% forests and woodlands, and 39% other. The country's most important natural resources are bauxite, gypsum, and limestone. Major exports include alumina, bauxite, sugar, bananas and rum. All electricity is produced by generators powered by fossil fuels. Jamaica has 370 km of railways, 207 km public (no longer operational) and 163 km privately owned and used to carry bauxite. It has 19,000 km of highways, 13,440 km of which are paved, and 36 airports, 11 with paved runways. In recent years, cocaine transshipment to the U.S. and Europe and cannabis production have increased local crime and strained international relations.

2. Climate. Jamaica's climate is tropical, hot and humid, with temperate conditions in the interior of the island. It has a combined average total rainfall of about 95 cm per year. Its average daily temperatures are 27°C to 35°C (May through September) and 21°C to 27°C (October through April). Hurricanes and tropical storms may strike Jamaica from July to November, often causing severe damage and loss of life.

Kingston (elevation 34 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	30	30	30	31	31	32	32	32	32	31	31	31

MINIMUM	19	19	20	21	22	23	23	23	23	23	22	21

Monthly Precipitation (liquid equivalent)

MEAN (mm)	23	15	23	31	102	89	89	91	99	180	74	36

3. Population and Culture. Jamaica's population was estimated in July 2000 to be 2,652,689 persons, about 245 persons per sq km. Ethnically, the population is 90.9% black, 7.3% mixed, 1.3% East Indian, 0.2% white, 0.2% Chinese, and 0.1% other. The literacy rate is 85%, and average life expectancy at birth is just over 75 years. The population is approximately 52% urbanized. Religious preferences include: 61.3% Protestant (at least ten denominations), 4% Roman Catholic, and 34.7% other (including some spiritual cults). Roughly 50% of the population also practices voodoo. The work force is employed: 50.5% in services, 42.1% in industry, and 7.4% in agriculture. Current unemployment is estimated at 15.5%.

4. Sanitation and Living Conditions. There are stark differences in living standards between the wealthy minority and the rest of the people. The rich have luxuries and conveniences, while the majority of the population has far less access to consumer goods and services. Many are extremely poor. The family is very important, but single parents and absentee fathers are common. Some women choose to be single parents. Many women hold higher positions in economic and political circles than in the past and have assumed more influence in the government. Gang violence and crime are serious problems in the slums of Kingston. Public transportation and roads are poor and unsafe. Vehicles travel on the left side of the road. Streets, including the main road to the airport, may be blocked for indefinite periods, without warning, by roadblocks, bonfires, or street dances. Theft and violent crime is common in most cities and anywhere outside the tourist enclaves of Kingston and Montego Bay.

The economy, ranked in the lower half in the world, is stagnant and may be declining slightly. Contributing factors include tight money and fiscal policies, growing internal national debt, increasing international trade and monetary deficits, high crime rates, and increasing civil unrest. Private medical care is available and adequate in and around Kingston and Montego Bay, but substandard throughout the rest of the country.

Most of the country's water and sewage treatment systems are inadequate and poorly maintained. Drinking water supplies and food are often contaminated by raw sewage or industrial waste. Food-borne and water-borne diseases, including typhoid fever, enteric bacterial diseases and hepatitis A, are common. Ciguatera poisoning occurs frequently. Widespread environmental problems include: heavy deforestation, pollution of coastal waters and destruction of coral reefs by raw sewage, industrial wastes (especially from mining and smelting bauxite), and spilled oil. Air pollution by vehicle emissions is an increasing problem, especially in Kingston.

O. Martinique.

1. Geography. Martinique has a total land area of 1,060 sq km, about six times the size of Washington, DC. It is a territory of France that lies north of Trinidad and Tobago, near the center of the Windward Islands of the Lesser

Antilles. It is mountainous with an indented coastline and a dormant volcano. However, volcanic activity is a serious hazard to inhabitants of the island. The economy is based on sugarcane, bananas, tourism, and light manufacturing. Massive material and financial aid from France is needed annually to offset Martinique's trade deficit. Banana exports are increasing, but sugar is now largely converted into rum instead of exported. The country's highest point is 1,397 m at Montagne Pelée, near the northwest end of the island. Land use includes: 8% arable (40 sq km of which are irrigated), 8% permanent crops, 17% permanent pasture, 44% forests and woodlands, and 23% other. The country's most important natural resources are coastal scenery and cultivable land. Electricity is produced by generators powered by fossil fuels. Roughly 90% of the population is of African or mixed origin, and 95% are Roman Catholics. More than 70% of the labor force is employed in services and administration. The country has 2,724 km of roads, most of which are paved, and two airports, one with paved runways.

2. Climate. Martinique's climate is tropical, moderated by trade winds, with a rainy season annually from June to October, and a drier period from December to May. The average total rainfall is about 205 cm per year. Average daily temperatures vary only slightly from 27.3°C, being cooler from December to May and at higher elevations. Tropical storms and hurricanes may pass over the island from June through November, averaging one devastating storm every eight years.

Fort-de-France, Martinique (elevation 4 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	28	29	29	30	31	30	30	31	31	31	30	29
MINIMUM	21	21	21	22	23	23	23	23	23	23	22	22

Monthly Precipitation (liquid equivalent)

MEAN (mm)	119	109	74	99	119	188	239	262	236	246	201	150

3. Population and Culture. Martinique's population was estimated in July 2000 to be 414,516 persons, or slightly more than 391 persons per sq km. Ethnically, the population is 90% black or mixed, 5% white, and < 5% other (East Indian, Lebanese, and Chinese). The literacy rate is 93%, and the average life expectancy at birth is slightly more than 78 years. Religious preferences include 95% Roman Catholic and 5% Hindu and pagan African. The workforce is employed: 73% in service and tourism, 17% in light industry (e.g., making rum), and 10% in agriculture (mainly bananas or sugarcane). Unemployment is about 24%.

4. Sanitation and Living Conditions. The people of Martinique enjoy a rather high standard of living, with modern communications systems, transportation, and electronic devices all readily available. Medical care is also available throughout the country, although it does not equal that of more industrialized countries. Food-borne and water-borne diseases occur occasionally, as does ciguatera poisoning. Except in remote mountainous areas, roads are generally in good condition and include some six-lane highways.

P. Montserrat.

1. Geography. Montserrat has a total land area of 100 sq km and is about 0.6 times the size of Washington, DC. It is a territory of the United Kingdom and lies 48 km southwest of Antigua, near the southern end of the Leeward Islands. Montserrat is a mountainous, volcanic island with limited coastal lowlands. The country's economy has historically been based on agriculture, but crop destruction due to hurricanes and volcanic activity (since 1995) have severely limited agricultural production. A volcano in the Soufriere Hills became active on 18 July 1995, had a catastrophic eruption in June 1997, and still remains active (a dome collapse and related ash-fall occurred in July 2001). Much of the island was devastated and an estimated 65% of its residents (8,000 people) fled due to these eruptions. Some former residents have returned to the northern half of the island. Tourism, mainly by rich and famous people attracted to the island's luxuriant flora and tropical climate, accounts for about 20% of the gross domestic product. However, volcanic activity has restricted access, which since 1997 has been limited to ferries and helicopters from Antigua. British reconstruction aid has helped the island's economy. The country's highest point is 914 m at Chances Peak (in the Soufriere Hills), near the center of the southern half of the island. Land use includes: 20% arable, 10% permanent pasture, 40% forests and woodlands, and 30% other. The country has negligible natural resources and limited cultivable land. Serious soil erosion occurs on land cleared for cultivation. Electricity is produced exclusively by generators powered by fossil fuels. The country has 269 km of roads, 203 km of which are paved, and one airport with short paved runways, but safety factors prevent landing by most fixed-wing aircraft.

2. Climate. Montserrat's climate is tropical and humid, with very little change in temperatures year round. The rainy season, with a risk of tropical storms and hurricanes, occurs from June to November. The average total rainfall is about 145 cm per year. Average daily temperatures vary only slightly, from 27°C in summer to 24°C in winter.

Plymouth, Montserrat (elevation 40 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	28	33	29	30	31	31	31	31	32	31	29	28
MINIMUM	21	21	21	22	23	24	24	24	23	23	23	22

Monthly Precipitation (liquid equivalent)

MEAN (mm)	122	86	112	89	97	112	155	183	168	196	180	140

3. Population and Culture. Montserrat's population was estimated in July 2000 to be 6,409 persons, or slightly more than 64 persons per sq km. An indefinite number of those have returned since 1998. The population consists of blacks and whites, though proportions are unknown. The literacy rate is 97%, and the average life expectancy at birth is nearly 78 years. Religious preferences include undetermined numbers of Anglicans, Methodists, Roman Catholics, Pentacostals, Seventh-Day Adventists, and other Christian denominations. Most people (81%) are employed in services related to tourism, although industry (e.g., electronic components, plastic bags) and agriculture (e.g., vegetables, cattle) account for 13.6% and 5.4% of those employed. The local government has been developing the island as an offshore data processing and financial center. Unemployment is about 20%.

4. Sanitation and Living Conditions. The people of Montserrat enjoy a relatively high standard of living, with modern communications systems and electronic devices fairly readily available. Housing has been scarce throughout the island since volcanic activity began in 1995, despite increased construction near the island's northern end. Medical care is limited and substandard throughout the country. The primary hospital was destroyed in a volcanic eruption and has been replaced by a temporary one near the northern end of the island. Outbreaks of food-borne and water-borne diseases occur occasionally, as well as ciguatera poisoning. Roads are in fair-to-good condition, but many in mountainous areas are steep, narrow and winding.

Q. Navassa Island.

1. Geography. Navassa Island is an uninhabited rocky island in the Caribbean Sea. It has a total land area of 5.2 sq km and is about 9 times the size of the Capital Mall in Washington, DC. It is strategically located 160 km south of the U.S. Naval Base at Guantanamo Bay, Cuba, and is about 1/4 of the way from Haiti to Jamaica. It is an unincorporated territory of the U.S. and is administered by the U.S. Fish and Wildlife Service. Navassa Island is a raised coral and limestone plateau that is flat to undulating and ringed by vertical cliffs 9 to 15 m high. There is one depression in the shore cliffs near the northwestern end of the island where phosphorite miners had built a short wharf for loading the mineral onto ships. The island's highest point is 77 m at an unnamed site near its southwestern side. Most of the island is covered by shrubs and short trees, predominantly by an indigenous species of fig and by poisonwood (*Metopium toxiferum*, family Anacardiaceae). The limited grasses on the island once supported a small herd of goats. The island has many limestone karst formations and many steep-walled pits 3 to 4 m deep, often with small caves in their sides.

Navassa Island was discovered by Christopher Columbus in 1504 and named "Navaza." Over the years, birds and possibly bats have deposited large amounts of guano (several m thick in places) that have gradually changed into a reddish, granular, phosphate-rich material called "phosphorite." Navassa Island was claimed by the U.S. in 1857 under provisions of the "Guano Act." The Navassa Phosphate Co., Baltimore, MD, occupied the island and mined the phosphorite from 1865 to 1900, when the supply dwindled and further retrieval became uneconomical. In 1917, the U.S. Coast Guard built and manned the tallest Caribbean lighthouse on Navassa Island. In 1999, the island and lighthouse were decommissioned as a Coast Guard checkpoint. In 1998, the island became a wildlife refuge under the Center for Marine Conservation. Haiti claims Navassa Island as its territory.

2. Climate. Navassa Island's climate is tropical and humid, with very little change in temperature year round. It lies in the middle of the Caribbean hurricane belt, and there is a risk of tropical storms and hurricanes from June to November. There are no reliable long-term records of average or annual temperatures and rainfall, but these could be expected to be similar to those for coastal areas of nearby Haiti.

3. Population and Culture. Navassa Island is uninhabited.

4. Sanitation and Living Conditions. There is one large, abandoned, 46-m tall lighthouse near the southwestern side of the island and a few small, dilapidated buildings near the southeastern side. The buildings were originally constructed by miners in the late 1800s and rebuilt in 1917 by the U.S. Coast Guard. They include at least two underground freshwater (rain catchment) storage cisterns. There is no other freshwater source. There are no large trees for shade and no significant topographic relief for protection from wind or storms. Occasionally, fishermen from Haiti or Jamaica visit the island and may camp near the old buildings for a night or two.

R. Netherlands Antilles.

1. Geography. The Netherlands Antilles comprise two groups of islands (five main islands) in the Caribbean Sea that are part of the Kingdom of the Netherlands. One group includes Curaçao and Bonaire, both within 70 km of the northern coast of Venezuela. The other group, located east of the Virgin Islands near the middle of the Leeward chain of the Lesser Antilles, includes Saba, Saint Eustatius, and Saint Maarten (the southern part of the island of Saint Martin; the northern part is a French territory, Saint-Martin). The Netherlands Antilles has a total land area of 960 sq km, which is more than five times the size of Washington, DC. The islands are generally hilly with volcanic interiors. The country's highest point is 862 m at Mount Scenery. The island of Saint Maarten also has 10.2 km of land border with Saint-Martin (part of the French territory of Guadeloupe), which divides the Island of Saint Martin approximately on an east-west line. Only 10% of the land is arable. The country's most important natural resources are phosphates (Curaçao only) and salt (Bonaire only). Curaçao was the center of the Caribbean slave trade and was hard hit by the abolition of slavery in 1863. Its prosperity (and that of neighboring Aruba) was restored in the early 20th century when oil refineries were constructed to service the newly discovered Venezuelan oil fields. The economy is based on tourism, petroleum transshipment, and offshore finance and is highly integrated with the world economy. These islands have a high per capita income and a well-developed infrastructure compared to other countries in the region. However, unemployment is rather high for a developed country. Almost all consumer and capital goods are imported, mainly from Venezuela, the U.S. and Mexico. Poor soils and inadequate water supplies limit the development of agriculture. All of the country's electricity is produced by generators that run on fossil fuel. The country has 600 km of roads, 300 km of which are paved. There are five airports, all with paved runways. There are also three major seaports located at Kralendijk, Phillipsburg, and Willemstad.

2. Climate. The climate of the Netherlands Antilles is tropical but tempered by trade winds. Curaçao and Bonaire lie south of the hurricane belt and are rarely threatened by severe tropical storms, but Saint Maarten, Saint Eustatius, and Saba are subject to hurricanes from July to November each year. Temperatures seldom exceed 32°C in the daytime and seldom fall below 24°C at night. Total rainfall averages about 56 cm per year.

Willemstad, Curaçao (elevation 23 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	28	29	29	30	30	31	31	31	32	31	30	29
MINIMUM	24	23	23	24	25	26	25	26	26	26	24	24

Monthly Precipitation (liquid equivalent)

MEAN (mm)	53	25	20	28	20	25	38	31	28	107	112	99

3. Population and Culture. The population of the Netherlands Antilles was estimated in July 2000 to be 210,134 persons or nearly 219 persons per sq km. The population is 85% black or mixed and 15% other (including Carib Amerindian, white, and East Asian). The literacy rate is 98%, and the average life expectancy at birth is more than 74 years. Religious preferences include: Roman Catholic, Jewish, and various Protestant denominations, including Seventh-Day Adventist.

4. Sanitation and Living Conditions. The standard of living for most of the population is relatively high. The country's economy is strong, and most consumer goods and modern conveniences are readily available. Roads and transportation are good, but road signs may not be easily seen. Medical care is generally available throughout the country, especially on Saint Maarten and Curaçao, but it is not comparable to care routinely available in the U.S. Food-borne and water-borne diseases are significant public health threats. Outbreaks of ciguatera poisoning also occur. The relatively low average annual rainfall leads to dusty conditions on some of these islands.

S. Puerto Rico.

1. Geography. Puerto Rico is the smallest and the easternmost island in the Greater Antilles. It has a total land area of 8,959 sq km and is about three times the size of Rhode Island. Puerto Rico is a commonwealth of the U.S. Its highest point is 1,338 m at Cerro de Punta, near the middle of the western half of the island. The terrain is mostly mountainous with a fertile coastal plain along the north side of the island. Precipitous drops from the mountains to the sea occur along the west coast, and sandy beaches are present along most coastal areas. The economy is one of the most dynamic in the Caribbean region and is based primarily on tourism, a variety of industries, and agriculture (especially dairy and sugar production). More than half of the labor force is employed in government services and tourism. Historically, special tax relief, cheap labor, and Puerto Rico's role as an export processing zone for U.S. goods have provided a business-friendly atmosphere encouraging expansion of industry and trade. Land use includes: 4% arable (about 390 sq km are irrigated), 5% permanent crops, 26% permanent pasture, 16% forests and woodlands, and 49% other. The country's most important natural resources are copper, nickel, and possibly onshore and offshore oil reserves. Electricity is produced by generators powered by fossil fuels (98.06%) or by hydroelectric generators (1.94%). Droughts and hurricanes are serious natural hazards and soil erosion is a growing problem. Puerto Rico has 96 km of private railroads that are mainly used to transport sugarcane. It has 14,400 km of paved roads and 30 airports, 21 with paved runways. It is strategically located along the Mona Passage, a key shipping lane to the Panama Canal. San Juan has one of the largest and best natural harbors in the Caribbean. Many small rivers and the high central mountains ensure that the land has an abundant supply of water.

2. Climate. Puerto Rico's climate is tropical marine and mild, with little seasonal variation in temperature. Relatively constant northeastern trade winds blowing year-round help moderate the tropical heat and humidity. The average total rainfall is about 140 cm per year, with slightly more occurring from May to November, though there is no distinct dry season. The northern side of the island receives more rain than the southern side, which is relatively dry, especially the southwestern corner. Average daily temperatures in coastal areas vary only a few degrees from 24°C, but higher elevations are cooler. Hurricanes and tropical storms may strike the island from June through November.

San Juan (elevation 25 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	27	27	27	28	29	29	29	29	30	29	29	27
MINIMUM	21	21	21	22	23	24	24	24	24	24	23	22

Monthly Precipitation (liquid equivalent)

MEAN (mm)	109	69	74	104	150	137	145	160	158	142	160	137

3. Population and Culture. The population of Puerto Rico was estimated in July 2000 to be 3,915,798 persons, or slightly more than 437 persons per sq km. Ethnically, the population is diverse and includes people of black, white, and Amerindian ancestry, among others. The literacy rate is 89%, and the average life expectancy at birth is about 75 years. Religious preferences include 85% Roman Catholics and 15% Protestants and others.

4. Sanitation and Living Conditions. Puerto Rico is considered to be a developing area, but the standard of living for most of its people is good. The economy is expanding and is ranked among the upper 50% in the world. Modern conveniences, communications systems, transportation, and consumer goods are readily available to most of the people. In and near San Juan, medical care is available and comparable to that in the U.S. Medical care is less available and of poorer quality throughout the rest of the island. Water shortages and droughts occasionally occur. Most of the country's water and sewage treatment systems are adequate, and food-borne and water-borne diseases are uncommon compared to other Caribbean nations. Most roads are adequate and are kept in fair to good condition. Some roads in remote or mountainous areas are narrow and winding.

T. Saint Kitts and Nevis.

1. Geography. The country of Saint Kitts and Nevis has a total land area of 261 sq km, which is about 1.5 times the size of Washington, DC. It lies near the southeastern end of the Leeward Islands. Nevis is separated from Saint Kitts by a 3.2 km wide channel and is more lush and less developed. There is regular ferry service between the islands. The airport on Saint Kitts is large enough for international jet flights to land, but the airport on Nevis can only accommodate small propeller planes. The country's highest point is 1,156 m at Mount Liamuiga (a dormant volcano with a 227 m deep crater), near the middle of the northwestern half of the island of St. Kitts. Both islands are mainly volcanic with mountainous interiors. The economy is expanding and currently ranks in the upper 50% in the world. It has traditionally depended on the growing and processing of sugarcane, but decreasing world prices have depressed this industry in recent years. Tourism, export-oriented manufacturing, and offshore banking have recently assumed larger roles in the economy. Most food, fuel, machinery, and consumer goods must be imported. Land use includes: 22% arable, 17% permanent crops, 3% permanent pasture, 17% forests and woodlands, and 41% other. The warm, tropical climate, lush vegetation, sandy beaches, and hot and cold springs attract many tourists to the islands. Generators powered by fossil fuels produce all of the country's electricity. Saint Kitts and Nevis has 58 km of railroads, mainly serving sugarcane plantations. It has 320 km of roads, 136 km of which are paved and 2 airports, both with paved runways. This country's small paramilitary unit, within its police force, contributed troops to the 1983 joint task force that invaded Grenada to remove a Marxist group which had seized power.

2. Climate. The climate of Saint Kitts and Nevis is tropical but tempered by constant sea breezes. There is little seasonal temperature variation, with a range of 17°C to 31°C throughout the year, but a distinct rainy season occurs from May through November. The average total rainfall is about 140 cm per year. Hurricanes and tropical storms may pass over the islands from July to November. In September 1998, Hurricane Georges caused roughly $445 million in damage.

3. Population and Culture. The population of Saint Kitts and Nevis was estimated in July 2000 to be 38,819 persons, or nearly 149 persons per sq km. The population is predominantly black but also includes people of British, Portuguese and Lebanese ancestry. The literacy rate is 97%, and the average life expectancy at birth is slightly less than 71 years. The population is about 41% urbanized. Religious preferences include Anglican, various other Protestant denominations, and Roman Catholic. About 70% of the workforce is employed in services and tourism. Unemployment is low and currently less than 5%.

4. Sanitation and Living Conditions. Saint Kitts and Nevis is a developing country, but the standard of living for most of its people is very good. The economy is expanding and is ranked among the upper 50% in the world. Modern conveniences, communications systems, transportation, and consumer goods are available to most of the people. Medical care is substandard, even in the capital of Basseterre, and is available primarily in or near urban areas. Most of the country's water and sewage treatment systems are adequate, but outbreaks of food-borne and water-borne diseases still occur. Ciguatera poisoning is a periodic problem. Most roads are adequate, but they are kept in only fair to good condition, especially outside urban areas. Some roads in remote or mountainous areas are narrow, winding and poorly marked. Vehicles drive on the left-hand side of the road.

U. Saint Lucia.

1. Geography. Saint Lucia has a total land area of 610 sq km and is about 3.5 times the size of Washington, DC. The island lies between St. Vincent and Martinique, north of Trinidad and Tobago, near the middle of the Windward Islands. Saint Lucia is volcanic and mountainous with some broad, fertile valleys. It has a very good natural harbor at Castries. The international airport at the southern tip of the island can accommodate jumbo jets. Significant amounts of pristine rainforest, natural attractions such as the twin pitons south of Soufriere, and the inaccessibility of much of the island's interior have made it a popular destination for ecotourists. Current environmental issues include deforestation and soil erosion, particularly in the northern region. The country's highest point is 950 m at Mount Gimie, approximately in the middle of the southern half of the island. Land use includes: 8% arable (about 10 sq km are irrigated), 21% permanent crops, 5% permanent pasture, 13% forests and woodlands, and 53% other. The country's most important natural resources are forests, sandy beaches, minerals (pumice), mineral springs, and geothermal energy from volcanic activity. Electricity is produced exclusively by generators powered by fossil fuels. The economy has historically been based on agriculture (mainly bananas), but recent changes in banana import preference policies by the European Union (EU) have caused that industry to decline steadily over the past few years. Saint Lucian farmers cannot compete with the much cheaper bananas from South American sources. However, about 40% of the labor force is still employed in agriculture. Saint Lucia's manufacturing sector is very diverse, the construction industry is growing, and the government is developing regulations to encourage the small offshore financial sector. Tourism is still relatively small but is growing in economic importance. Unemployment is about 15%. Saint Lucia has 1,210 km of roads, only 63 km of which are paved, and two airports, both with paved runways.

2. Climate. Saint Lucia's climate is tropical, moderated by trade winds, with dry (January through April) and rainy (May through August) seasons. During the dry season, sheltered parts of the island can experience intense heat, but higher elevations are generally cooler year-round. Most of the island has an annual average temperature of about 26°C; temperatures are slightly warmer May through July and slightly cooler December through February. Most of the island, especially near the southern and eastern shores, experiences very little temperature variation within a day. The total annual rainfall ranges from 150 to 350 cm per year, most falling during the rainy season. Heaviest rainfall occurs at higher elevations. Hurricanes and tropical storms are most likely to hit Saint Lucia from June through November.

Soufriere, Saint Lucia (elevation 3 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	28	28	29	31	31	31	31	31	31	31	29	28
MINIMUM	21	21	21	22	23	23	23	23	23	22	22	21

Monthly Precipitation (liquid equivalent)

MEAN (mm)	135	91	97	86	150	218	236	269	252	236	231	198

3. Population and Culture. The population of Saint Lucia was estimated in July 2000 to be 156,260 persons, or slightly more than 256 persons per sq km. Ethnically, the population is 90% black, 6% mixed, 3% East Indian, and 1% white. The literacy rate is 67%, and the average life expectancy at birth is about 72.31 years. Strong family and extended family concerns are important in the daily life and culture of most inhabitants, although absentee fathers are common in agricultural and remote locations. In recent years, women have gained increased educational and professional opportunities. The population is approximately 47% urbanized. Religious preferences include: 90% Roman Catholic, 3% Anglican, and 7% various other Protestant denominations.

4. Sanitation and Living Conditions. The standard of living for most of Saint Lucia's population is relatively good, with an expanding economy ranked among the upper 50% in the world. The availability of modern communications systems, transportation, electronic devices and other consumer goods is increasing. Medical care is available throughout the country but is substandard compared to most industrialized countries. Potable water is sometimes scarce due to inadequate local water and sewage treatment and improper disposal of solid waste. Gastrointestinal diseases caused by food-borne and water-borne pathogens occur occasionally, as does ciguatera poisoning. Roads, especially in mountainous areas, are narrow and winding and have narrow or no shoulders, few guardrails and steep ditches. Road maintenance is only fair to good, even in urban areas. Vehicles travel on the left-hand side of the road.

V. Saint Vincent and the Grenadines.

1. Geography. The country of Saint Vincent and the Grenadines includes the main island of Saint Vincent and more than 30 smaller islands (the Grenadines), several of which are uninhabited. It has a total land area of 389 sq km, about twice the size of Washington, DC. It lies between Saint Lucia and Grenada, north of Trinidad and Tobago, near the southern end of the Windward Islands. The administration of the islands of the Grenadines is divided between the government of Saint Vincent and the Grenadines and Grenada. Saint Vincent is a mountainous volcanic island. The other islands are flat and mainly bare coral. The country's highest point is 1,234 m at Soufriere, near the northern end of Saint Vincent island. The active volcano at Soufriere last erupted in 1979. Land use includes: 10% arable (about 10 sq km are irrigated), 18% permanent crops, 5% permanent pasture, 36% forests and woodlands, and 31% other. The country's electricity is produced partly by generators that run on fossil fuel (67.19%) and partly by hydroelectric generators (32.81%). The economy of Saint Vincent and the Grenadines has historically been based on agriculture, primarily banana production. The economy is growing slowly and is ranked in the lower half of the world's economies. Tourism and related services are expanding, although most tourists are the rich international jet set. The government has targeted improvements and services on the island of Mustique (accommodations for the wealthy) and Union Island (support for yachting) specifically to attract more tourists. There is a small manufacturing sector and a small but growing offshore financial sector. Unemployment is about 22%. Saint Vincent and the Grenadines has 1,040 km of roads, only 320 km of which are paved, and six airports, five with paved runways.

2. Climate. The climate of Saint Vincent and the Grenadines is tropical, with little seasonal variation in temperature, although there is a rainy season from May to November. Total rainfall throughout most of this country averages about 150 cm per year, with greater amounts at higher elevations. There is some rainfall nearly every day. Average daily temperatures are usually about 26°C year-round but may be slightly cooler from January through March and slightly warmer from July through September. Saint Vincent and the Grenadines lies at the southern margin of the hurricane belt, but severe storms strike these islands from June through November. Tropical storms wiped out substantial portions of the crops in both 1994 and 1995.

3. Population and Culture. The population of Saint Vincent and the Grenadines was estimated in July 2000 to be 115,461 persons, or more than 296 persons per sq km. Ethnically, the population is 66% black, 19% mixed, 6% East Indian, and 2% Carib Amerindians. Most of the population is descended from Africans brought over to work plantations from the 16th to 19th centuries. Family life and culture are heavily influenced by the Anglican Church, and due to a long history of intermarriage, there is little if any racial tension. Family life and extended families are strong, but cases of absentee fathers are frequent. The literacy rate is 96%, and the average life expectancy at birth is about 72.3 years. The population is approximately 43% urbanized. Religious preferences include: 47% Anglican, 28% Methodist, 13% Roman Catholic, 12% other (including Seventh-Day Adventist, and other Protestant denominations, as well as a few Hindus) .

4. Sanitation and Living Conditions. The standard of living for most of the population is relatively good, despite a slow-growing economy. Availability of modern communications, transportation, and most consumer goods is limited but increasing. Medical care is available throughout the country but is substandard compared to the U.S. Evacuation of critical medical cases can be slow and difficult. Potable water is sometimes scarce due to lack of any local sources on most of the islands. Most of the Grenadines must import all of their potable water and fuel. Indiscriminate sewage and solid waste disposal from yachts sometimes pollutes beaches, poses health hazards to tourists, and kills local reef corals and related sea life. Food-borne and water-borne diseases are significant public health risks. Despite significant government efforts to improve the transportation infrastructure, most roads are still narrow and winding, have no shoulders, traverse steep ravines (in mountainous areas), and are inadequately maintained. Vehicles drive on the left-hand side of the road.

W. Trinidad and Tobago.

1. Geography. The country of Trinidad and Tobago has a total land area of 5,128 sq km, which is slightly smaller than Delaware. This country lies just off the northeast coast of Venezuela, at the farthest southern end of the Windward Islands. The terrain is primarily plains with some hills and low mountains. The country's highest point is 940 m at El Cerro del Aripo, roughly centered (east and west) about 25 km south of Trinidad's northern coast. Land use includes: 15% arable (about 220 sq km irrigated), 9% permanent crops, 2% permanent pasture, 46% forests and woodlands, and 28% other. The country's most important natural resources are petroleum, natural gas and asphalt. Trinidad's Pitch Lake is the world's largest natural reservoir of asphalt. Trinidad is rich in tropical vegetation and has excellent beaches and a unique flora and fauna that includes more than 500 species of butterflies. Electricity is produced primarily by generators powered by fossil fuels (99.27%), but also partly by other means such as solar and wind (0.73%). Currently, the economy is based mainly on the petrochemical industry, foreign investment and trade, and tourism (especially pleasure boats). Unemployment remains rather high, despite government efforts to diversify the economy. Pollution of coastal waters, beaches and natural areas (coastal swamps) by spilled petroleum and waste from ships, water pollution by agricultural chemicals, industrial wastes, and raw sewage, deforestation and soil erosion are major environmental concerns. More than 60% of the labor force is employed in services (which account for more than half of the annual gross domestic product), 25% in construction, manufacturing and mining, and less than 10% in agriculture. Unemployment is about 14.2%. Trinidad has only a minimal agricultural railroad system near San Fernando, which has not been used since 1968. Trinidad and Tobago has 8,320 km of roads, 4,252 km of which are paved, and six airports, three with paved runways.

2. Climate. The climate is tropical with a rainy season from June to December and a dry season from January to mid-April. The average total rainfall is nearly 150 cm per year. Average daily temperatures usually vary from 21°C to 31°C, being coolest from January to March and warmest from April to June. Trinidad and Tobago lie outside the Caribbean hurricane belt and are seldom threatened by tropical storms.

St. Clair, Trinidad (elevation 20 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	31	31	32	32	32	32	31	31	32	32	32	31
MINIMUM	21	20	20	21	22	22	22	22	22	22	22	21

Monthly Precipitation (liquid equivalent)

MEAN (mm)	69	41	46	53	94	193	218	246	193	170	183	125

3. Population and Culture. The population of Trinidad and Tobago was estimated in July 2000 to be 1,175,523 persons, or slightly more than 299 persons per sq km. Ethnically, the population is 39.5% black, 40.3% East Indian (mainly immigrants from northern India), 18.4% mixed, 0.6% white, and 1.2% Chinese and other. The literacy rate is 97.7%, and the average life expectancy at birth is nearly 68 years. The population is approximately 70% urbanized. Religious preferences include: 29.4% Roman Catholic, 23.8% Hindu, 10.9% Anglican, 5.8% Muslim, 3.4% Presbyterian, and 26.7% other.

4. Sanitation and Living Conditions. The standard of living for most of the population of Trinidad and Tobago is relatively good due to an expanding economy and the ready availability of modern communications systems and most consumer goods. Adequate medical care is available in the capital, Port-of-Spain, but is less available in rural areas. Potable water is often scarce due to inadequate local water and sewage treatment and improper solid waste disposal. Food-borne and water-borne diseases are still a public health threat. Ciguatera poisoning occurs periodically. Some of Trinidad and Tobago's main roads are very good, and a few have four lanes. Most secondary roads are narrow and often have no shoulders or guardrails. Vehicles drive on the left-hand side of the road. Petroleum spills and raw sewage from ships have caused pollution of some of Trinidad and Tobago's coastal reefs and beaches and threaten populations of plants and animals in sensitive coastal marshes.

X. Turks and Caicos Islands.

1. Geography. The Turks and Caicos Islands is a territory of the United Kingdom comprising 32 low-lying flat limestone islands with extensive marshes and mangrove swamps. Only eight islands are inhabited. They are located about 40 km southeast of the Bahamas and about the same distance north of the island of Hispaniola in the Atlantic Ocean. The country has a total land area of 430 sq km, about 2.5 times the size of Washington, DC. The country's highest point is 49 m, at a location in the Blue Hills, near the western end of Providenciales Island. The economy is primarily based on tourism, fishing and offshore financial services. The country exports a considerable volume of seafood and sea shells, but most capital goods, food, fuel, and consumer goods must be imported. Only 2% of the land is arable. Electricity is produced exclusively by generators powered by fossil fuels. Natural fresh water sources are very limited and islanders depend on cisterns to collect rainwater for drinking. About one-third of the labor force is employed in government, one-fifth in agriculture and fishing, and the remainder work in tourism, financial, and other related services. Unemployment is estimated at 10%. The country has 121 km of roads, 24 km of which are paved, and seven airports, four with paved runways.

2. Climate. The climate of the Turks and Caicos Islands is tropical marine, moderated by northeastern trade winds, and is usually sunny and relatively dry. The average daily temperatures vary only a few degrees year-round, with high temperatures of about 31°C and low temperatures of about 22°C. The country's average total rainfall is about 95 cm per year, with most falling between October and November and slightly less falling between February and March. The Turks and Caicos Islands are located at the northern edge of the Caribbean hurricane belt. Hurricanes and tropical storms may occur between June and November but often veer north or northeast of the islands.

Grand Turk (elevation 3 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	27	27	28	29	30	31	31	32	31	31	29	28
MINIMUM	21	21	22	23	24	25	25	26	25	24	23	22

Monthly Precipitation (liquid equivalent)

MEAN (mm)	56	36	28	38	66	41	43	51	81	102	114	69

3. Population and Culture. The population of the Turks and Caicos Islands was estimated in July 2000 to be 17,502 persons, or almost 41 persons per sq km, and is nearly 100% black. The literacy rate is 98%, and the average life expectancy at birth is slightly more than 73 years. Religious preferences include: 41.2% Baptist, 18.9% Methodist, 18.3% Anglican, 1.7% Seventh-Day Adventist, and 19.9% other. Employed: 33% in government, 20% in agriculture, and 47% other (including tourism, financial and other services). Unemployment is about around 10%.

4. Sanitation and Living Conditions. The standard of living for most of the people of the Turks and Caicos Islands is relatively good. The economy depends heavily on annual subsidies from the UK. There is limited availability of modern conveniences and consumer goods. Medical care is substandard throughout the country. The country's water distribution, sewage treatment, and waste disposal are generally inadequate. Consequently, drinking water supplies are often contaminated by raw sewage or industrial waste. Food-borne and water-borne diseases are common as well as the threat of ciguatera poisoning.

Y. Virgin Islands.

1. Geography. The U.S. Virgin Islands are a group of 53 volcanic islands about 80 km east of Puerto Rico, at the western end of the Leeward Islands. They are an unincorporated territory of the U.S., with a total land area of 349 sq km, about twice the size of Washington, DC. The U.S. Virgin Islands' highest point is 474 m at Crown Mountain. The islands are hilly to rugged with little level land, although beautiful sandy beaches occur along several coastal areas. The U.S. Virgin Islands' economy is among the top 25% in the world and is based on tourism, which accounts for more than 70% of employment and more than 70% of the annual GDP. The manufacturing sector includes petroleum refining, textiles, pharmaceuticals, electronics, and watch assembly. Agriculture is insignificant. One of the world's largest petroleum refineries is on Saint Croix. Land use includes: 15% arable, 6% permanent crops, 26% permanent pasture, 6% forests and woodlands, and 47% other. Electricity is produced exclusively by generators powered by fossil fuels. The U.S. Virgin Islands have 856 km of roads and two airports, both with paved runways. This country is strategically located along the Anegada Passage, a key shipping lane for the Panama Canal. Saint Thomas has one of the best natural deepwater harbors in the Caribbean. A lack of natural fresh water resources is a major concern.

2. Climate. The climate of the U.S. Virgin Islands is subtropical, tempered by easterly trade winds, with relatively low humidity, little seasonal temperature variation and an annual rainy season (May through November). Average total annual rainfall is about 130 cm. Daily temperatures vary only a few degrees from the average of 26°C, seldom exceeding a low of 21°C or a high of 32°C. Higher elevations are cooler and may receive more rain. Hurricanes and tropical storms may strike these islands from June through November.

3. Population and Culture. The population of the U.S. Virgin Islands was estimated in July 2000 to be 120,917 persons, or slightly more than 346 persons per sq km. The population's ethnic origins are diverse, including blacks, whites, Asians and others. The average life expectancy at birth is about 78 years. Religious preferences include: 42% Baptist, 34% Roman Catholic, 17% Episcopalian, and 7% others.

4. Sanitation and Living Conditions. The U.S. Virgin Islands is a developed country. The standard of living for most of its people is very good. The economy is expanding and is ranked among the top 25% in the world. Modern conveniences, communications systems, transportation, and most consumer goods are readily available to most inhabitants. Medical care is available throughout the islands and is comparable to that in the U.S. Water shortages and droughts occur fairly often due to a lack of local freshwater sources. Most of the country's water and sewage treatment systems are adequate, and food-borne and water-borne diseases are infrequent. Most roads are adequate and are kept in fair to good condition, although roads in hilly or mountainous areas are narrow and winding.

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

A. Malaria.

Human malaria is caused by any of 4 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, falciparum malaria, can produce life-threatening complications, including renal and hepatic failure, cerebral involvement and coma. Case fatality rates among children and nonimmune adults exceed 10% when not treated. The other human malarias, vivax, malariae and ovale, are not life-threatening except in the very young, the very old, or persons in poor health. Illness is characterized by malaise, fever, shaking chills, headache and nausea. The periodicity of the fever, occurring daily, every other day, or every third day, is characteristic of the *Plasmodium* species. Nonfatal cases of malaria are extremely debilitating. Relapses of improperly treated malaria can occur years after the initial infection in all but falciparum malaria. *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. 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 Centers for Disease Control and Prevention (CDC), and the Armed Forces Medical Intelligence Center.

Military Impact and Historical Perspective. Malaria has had an epic impact on civilizations and military operations. During the U.S. Civil War, 50% of the white troops and 80% of the black troops in the Union armies contracted malaria annually. During World War I, in the Macedonian campaign, the French army was crippled with 96,000 cases of malaria. In 1918, over 2 million man-days were lost in the British Macedonian Army because of malaria. During World War II, malaria caused five times as many U.S. casualties in the South Pacific as did enemy action. The highest annual incidence rate of malaria during World War II (98.5 cases per 1,000) occurred in the China-Burma-India theater. There were approximately 81,000 confirmed cases of malaria in the U.S. 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 during the year, or the equivalent of an entire division lost for a month. In 1952, during the Korean War, the 1st Marine Division suffered up to 40 cases per 1,000 marines. However, chloroquine became available throughout the entire Korean combat area by the late summer of 1950. Consequently, the incidence of malaria during the Korean War was low when compared to the rates for World War II. During the Vietnam War, battle casualties accounted for only 17% of American hospitalizations. Many regiments were rendered ineffective due to the incidence of malaria, and many U.S. 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 250 to 300 million cases of malaria annually, with 2 to 3 million deaths. The WHO estimates that nearly 1 million children under the age of 10 in Africa 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 locations, with little or no risk in cities. However, in Somalia during Operation Restore Hope (1993), several malaria cases occurred in U.S. troops who were only in Mogadishu. Urban malaria has also become a serious problem in India due to the breeding habits of *Anopheles stephensi*.

Malaria has been eradicated throughout the Caribbean, with the exception of the island of Hispanola (Haiti and the Dominican Republic) and a recent resurgence of malaria in Trinidad. In some countries malaria has been eradicated since the 1960s (Puerto Rico and Grenada in 1962, Trinidad in 1965, except for recent resurgence). However, competent malaria vectors are present on many Caribbean islands, and at least 10 Caribbean countries have reported imported cases during the last 15 years. *Plasmodium falciparum* is the most frequently imported malaria, and Africa is the most common source of imported cases. In addition, all mainland countries bordering the Caribbean Sea are malaria-endemic, so the threat of reintroduction of malaria is high.

The French West Indies is a popular tourist destination. In 1996, a case of *P. falciparum* was reported in a patient returning to France after a visit to Guadeloupe. Thirty cases have been reported on Guadeloupe since 1995, although malaria had been considered eradicated there since 1970. Over 90% of these cases were clearly imported, and the island should not be considered an area with a risk of malaria. However, the presence of malaria vectors and the geographical and cultural proximity of countries where malaria is endemic, such as French Guiana and Haiti, should be considered if local transmission is suspected in the future.

The current distribution of malaria in the Caribbean is depicted in Figure 1.

Cuba. Officially, Cuba has been considered malaria-free by the World Health Organization since 1973, although up to several hundred cases are reported annually. The Cuban government officially classifies such cases as imported, but cases of malaria in people visiting Cuba continue to be reported.

FIG. 1. ENDEMIC AREAS OF MALARIA IN THE CARIBBEAN (SHADED AREAS).

Dominican Republic. Transmission is year-round and countrywide in rural areas below 400 m. Nearly all cases are falciparum malaria. After declining sharply in the early 1990s, total cases rebounded to exceed late 1980 levels during 1994 to 1995 (about 1,800 cases), and then declined again (800 to 900 cases) during 1996 to 1997. Incidence of malaria increased during 1998 as a result of flooding caused by Hurricane Georges. Over 3,000 cases were reported in 1999. Risk is highest in the extreme northwestern provinces bordering Haiti, but significant numbers of cases also occur in Distrito Nacional, Peravia Province, and La Altagracia Province. The risk in tourist resorts appears to be extremely low, although cases have been reported in tourists visiting the Bravo Beach area of La Altagracia Province and in a tourist area on the north coast east of Puerto Plata. Several cases have also been reported in tourists traveling to Punta Cana, a town on the eastern tip of the island, and in nearby beach resorts.

Haiti. Malaria is still a serious public health problem. Risk exists countrywide, including periurban areas, at elevations under 500 m. Risk of transmission is higher in northern parts of Haiti. There have been epidemics in coastal areas where the vector, *Anopheles albimanus*, was breeding in marshes at the edge of towns. *Plasmodium falciparum* accounts for 99% of cases, with the remainder attributed to *P. malariae*. *Plasmodium vivax* was last reported in 1987. Transmission occurs year-round. Seasonality of transmission is less marked in northern areas than in southern and central areas, where cases have historically peaked from October through January. From 1982 to 1991, a total of 5,521 malaria cases were diagnosed at central Haiti's Albert Schweitzer Hospital. Peak incidences occurred yearly from November to January. The results of the study showed a general decline in the annual number of malaria cases. A retrospective study of malaria cases in the Limbe River valley of northern Haiti from 1975 to 1997 also indicated a general decline since the mid 1980s. Falciparum malaria was a major problem among Haitian refugees coming to the U.S. From December 1991 to March 1992, 235 cases of falciparum malaria were diagnosed in displaced Haitians in temporary camps at the U.S. Naval Base, Guantanamo Bay, Cuba.

Although reports of chloroquine-resistant malaria in Haiti occurred mainly during the 1980s, they have not been confirmed. Recent studies have not demonstrated evidence of chloroquine resistance. However, during 1984, studies in Haiti on the susceptibility of *P. falciparum* to pyrimethamine attributed 30% of treatment failures to drug resistance. Treatment with pyrimethamine and sulfadoxine cured the pyrimethamine-resistant cases suggesting that the resistance level was low. Chloroquine and Fansidar™ (pyrimethamine sulfadoxine) tolerant malaria infections were reported in Cuban soldiers returning from Angola during the 1980s. Establishment of drug-resistant malaria is a threat, since most imported cases in the Caribbean come from Africa, where chloroquine-resistant strains are prevalent. Caribbean countries are also close to South American foci of multi-drug resistant malaria.

Trinidad. Over a 30-year period (1968 to 1997), 213 malaria cases were reported in Trinidad. Most were imported, although 2 clusters of indigenous transmission occurred on the island. During 1990 to 1991, an imported case of *P. vivax* from Venezuela initiated an outbreak associated with *Anopheles aquasalis.* Between August 1994 and September 1995, 22 cases of *P. malariae* were reported from the Naiva-Mayaro area of Trinidad. The focus of *P. malariae* was associated with the vectors *An. bellator* and *An.*

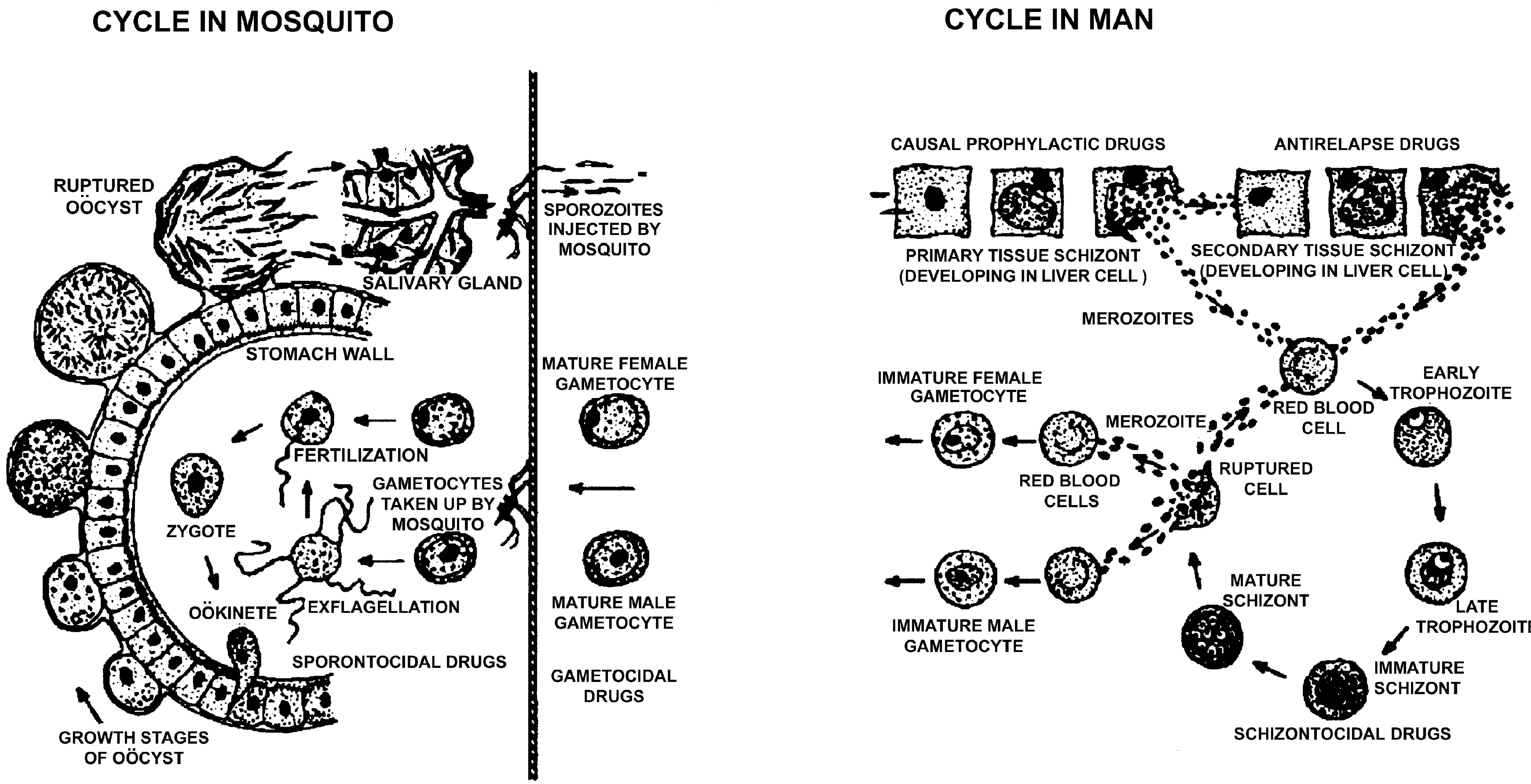
homunculus. Twelve cases of *P. malariae* were reported from Trinidad in 2000. All cases occurred in people who worked or resided in forested areas of southeast Trinidad.

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 in the mosquito. When a female *Anopheles* ingests blood containing the sexual stages (gametocytes) of the parasite, male and female gametes unite to form a motile ookinete that penetrates the mosquito's stomach wall and encysts on the outer surface of the midgut. Thousands of sporozoites are eventually released, and some of these migrate to the salivary glands. Infective sporozoites are subsequently injected into a human host when the mosquito takes a blood meal (Figure 2). The time between ingestion of gametocytes and liberation of sporozoites, ranging from 8 to 35 days, is dependent on the temperature and the species of *Plasmodium*. Malaria parasites develop in the mosquito vector most efficiently when ambient air temperatures are between 25°C and 30°C. Parasite development is prolonged during cool seasons and at high altitudes, and may exceed the life expectancy of the vector. Adult vector life span varies widely depending on species and environmental conditions. Longevity is an important characteristic of a good vector. Once infected, mosquitoes remain infective for life and generally transmit sporozoites at each subsequent feeding. Vector competence is frequently higher with indigenous strains of malaria. This may decrease the likelihood that imported strains from migrants will become established.

Vector Ecology Profiles.

General Bionomics. Female anopheline mosquitoes must ingest a bloodmeal for their eggs to develop. Feeding activity begins at dusk for many species, although many others feed only later at night or at dawn. Most anophelines feed on exposed legs, although 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 the bloodmeal and are deposited one at a time, primarily in clean water with or without emergent vegetation, depending on the mosquito species. A single female may deposit up to 300 eggs. Mosquito larvae feed on organic debris and minute organisms living in aquatic habitats. Oviposition sites include ground pools, stream pools, slow moving streams, animal footprints, artificial water vessels, and marshes. Deep water (over 1 m in depth) is generally unsuitable for larval development. There are 4 larval instars, and 1 to 2 weeks are usually required to reach 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. 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 per swarm. Males and females feed on plant sugars and nectar to provide energy for flight and other activities.

FIGURE 2. LIFE CYCLE OF *PLASMODIUM,* THE MALARIA PARASITE



Adult Feeding, Resting, and Flight Behavior. *Anopheles* spp. that are strongly attracted to humans are usually more important as vectors than those species that are strongly zoophilic. *Anopheles* generally fly only short distances from their breeding sites. The 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. Worldwide, about 70 species of *Anopheles* transmit malaria to man but only about 40 are important vectors. *Anopheles albimanus*, *An. crucians*, *An. grabhamii* and *An. vestitipennis* were the only species of *Anopheles* on the island of Hispaniola until 1986 when *An. pseudopunctipennis* was discovered for the first time in Haiti near Port-au-Prince. *Anopheles pseudopunctipennis* may now occur in other areas of the island. In Guadeloupe, French West Indies, *Anopheles albimanus* and *An. aquasalis* are the most important vector species. In Trinidad and Tobago, *An. aquasalis* and *An. bellator* are primary vector species of *P. vivax* and *P. malariae*, respectively, while *An. homunculus* is a potential vector species of *P. malariae*. *Anopheles albitarsis*, *An. punctimaculata*, and *An. oswaldoi* are also potential vectors on Trinidad. In Haiti, the Dominican Republic and Cuba, *An. albimanus* is the most important vector during sporadic outbreaks of *P. falciparum*, although *An. vestitipennis* is a potential secondary vector. *Anopheles albimanus* also occurs in Jamaica. *Anopheles grabhamii* was found in Cuba for the first time during the mid-1980s. It has become established on the island and is a potential secondary vector. *Anopheles crucians* and *An. vestitipennis* are possible secondary vectors in Cuba but have very low vectorial capacities. In Grenada and the lesser Antilles, *An. pseudopunctipennis* and *An. aquasalis* are malaria vectors. *Anopheles crucians* is reportedly a minor vector in the Dominican Republic.

Anopheles albimanus larvae inhabit a wide variety of sunlit fresh or brackish waters, such as pools, puddles, marshes, and lagoons that contain floating or grassy vegetation. *Anopheles albimanus* females bite humans and domestic animals most frequently outdoors but will enter houses and animal shelters to feed. Adults feed throughout the night, though feeding activity peaks around midnight. *Anopheles albimanus* usually rests outdoors after feeding. In Cuba, *Anopheles albimanus* adults rest in the open basements of buildings as well as under bridges surrounded by vegetation. Adults are more exophagic during rainy seasons when they are most abundant. In Haiti, peak abundance occurs between November and December, with a secondary peak in May. In northern Haiti, a 10-year study of the relationship between rainfall and incidence of malaria indicated a lag of 9 to 11 weeks between rainfall and new malaria cases. The lag period is the time required for creation of breeding sites after a rain, the life cycle of *An. albimanus*, and the incubation period for *P. falciparum*. The gonotrophic cycle averages about 2.6 days. The period from egg deposition to adult emergence requires about 15 days in the field. Adult males live for only 3 to 5 days, and adult females live for 5 to 11 days. *Anopheles albimanus* is an important vector despite its short longevity because it is usually very abundant. Adult females fly 1 to 2 km from breeding sites to find a bloodmeal.

In Trinidad, *Anopheles aquasalis* occasionally breeds in coastal fresh water pools but is normally found in brackish lagoons, salt water marshes, and tidal rivers or marshes. Temporary mangrove lagoons are more productive habitats than permanent ponds. Both shaded and unshaded habitats are utilized. Females bite humans and domestic animals indoors and outdoors but rest outdoors after feeding. *Anopheles aquasalis* adults peak at the end of the wet season, but substantial numbers extend into the early part of the dry season on Grenada. The oviposition patterns of *An. aquasalis* collected from a grass swamp in Gloudon, Caroni Swamp, Trinidad, indicated that oviposition is nocturnal, with 72% of the eggs laid between 2400 and 0400 hrs.

The diel pattern of oviposition of wild-caught *An. albitarsis*, derived from rice fields in Trinidad, was studied in the laboratory. Oviposition was almost exclusively nocturnal, with 79% of the eggs being laid during the scotophase. Wild-caught parous females allowed to engorge on human blood matured, on average, 71 follicles. Larvae breed in sunlit ponds, large pools, and marshes containing filamentous algae. Adults feed readily on humans and domestic animals indoors and outdoors but usually rest outdoors after feeding.

Anopheles bellator larvae breed only in leaf axils of bromeliads in partially shaded areas. Adults are anthropophilic and bite humans and domestic animals indoors and outdoors. They also rest in both areas after feeding. *Anopheles bellator* occurs particularly in the upland agricultural forests of Trinidad. The mean biting frequency of adults during one study in Trinidad was 60 per man-hour. *Anopheles bellator* deposits 65 to 79% of its eggs between 2200 and 0200 hrs. The first gonotrophic cycle averages about 82 hours, while subsequent cycles average 65 hours. Maximum female survival in the laboratory was 19 days, although most died within 10 days.

In Trinidad, landing collections of *An. homunculus* showed diurnal and nocturnal activity, with a single peak between 1600 and 2000 hrs. About 28% of *An. homunculus* were collected during the dry season and 72% during the wet season. Nearly identical seasonal parous rates were observed in wet (59%) and dry (56%) seasons.

Anopheles pseudopunctipennis is found from sea level to 2,500 m. In Grenada larvae inhabit small, sunny or partially shaded pools, grassy swamps, and the edges of streams. This species prefers shallow, stagnant water containing abundant filamentous green algae or aquatic vegetation. Adults are generally crepuscular and feed on humans and domestic animals, primarily outdoors. They usually rest outdoors after feeding but may move indoors for shelter at dawn after feeding during the night. *Anopheles pseudopunctipennis* is zoophilic and prefers to feed on large mammals, such as horses, cows and sheep, but will enter dwellings to feed on humans.

Anopheles vestitipennis larvae inhabit stagnant fresh water with emergent vegetation, primarily in coastal areas. Adults are anthropophilic and readily enter dwellings to feed on humans, with peak biting activity during the first 3 hours after sunset.

Anopheles crucians, *An. oswaldoi* and *An. punctimaculata* are insignificant vectors.

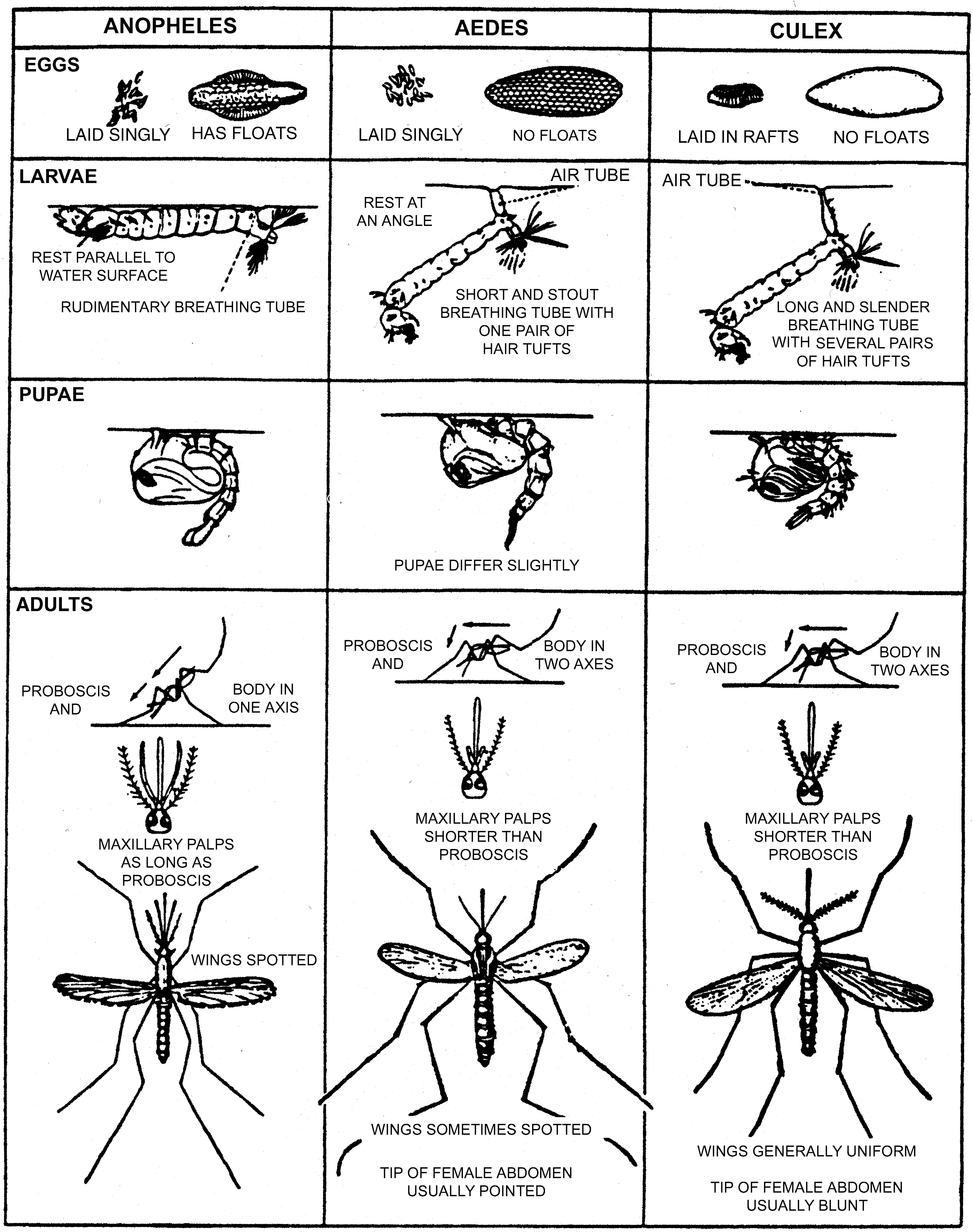
Vector Surveillance and Suppression. Light traps are used to collect night-biting mosquitoes, but not all *Anopheles* spp. are attracted to light. The addition of the attractant carbon dioxide to light traps increases the number of species collected. Traps baited with animals, or even humans, are useful for determining feeding preferences of mosquitoes collected. Adults are often 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 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 3). Adult *Anopheles* feed on the host with the body nearly perpendicular to the skin. Other genera of mosquitoes feed with the 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. Eggs are laid singly and float on the water surface. They are dark, about 1 mm in length, and in most species are boat-shaped with a pair of lateral floats. The shape, size and pattern of the floats can be used to distinguish closely related species. *Anopheles* larvae hang with the body parallel to the water surface by means of specialized palmate hairs that are unique to the genus. *Anopheles* are also the only mosquitoes that lack an air siphon. *Anopheles* larvae feed on micro-organisms and small particles floating on the water surface. Entomologists have exploited this feeding behavior 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 taken into consideration when surveying for mosquito larvae.

Malaria suppression includes elimination of gametocytes from the bloodstream of the human reservoir population, reduction of larval and adult *Anopheles* mosquito populations, use of **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 deployment. 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 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

FIGURE 3. *ANOPHELES, AEDES,* AND *CULEX* MOSQUITOES



relapses upon their return to the United States. 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. 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 malaria control, many vector populations are now resistant to insecticides (Appendix B, Pesticide Resistance in the Caribbean). Specially formulated larviciding oils can be used to control insecticide-resistant larvae. Pathogens, such as *Bacillus thuringiensis israelensis* and *B. sphaericus*, and insect growth regulators have also been used to control resistant larvae. However, there is growing evidence that resistance to these control agents has developed, 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. Rice needs considerable irrigation for high yields and this limits the possibilities for manipulating water to control mosquitoes. Well-designed drainage or flushing and careful timing of intermittent irrigation can control mosquito breeding but must be practical and economical to be accepted by farmers. Instead of draining, marshes can be excavated to form deep permanent impoundments with well-defined vertical banks that are unsuitable habitats for mosquito larvae. Other methods of source reduction can be utilized.

The proper use of repellents and other **personal protective measures** is thoroughly discussed in TG 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. The value of insect repellents is often forgotten by military personnel. Only a small proportion of U.S. soldiers (39 of 78 surveyed) used personal protective measures during training in 1998 at a multipurpose range complex in Yongp'yong, Republic of Korea, even though local Korean residents were contracting malaria. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. In China the use of treated bednets has largely replaced the spraying of residual insecticides on the walls of houses to prevent transmission of malaria. 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. See Appendix E for further information on **personal protective measures**.

B. Dengue Fever. (Breakbone fever, Dandy fever)
Dengue is an acute febrile disease characterized by sudden onset, fever for 3 to 5 days, intense headache, and muscle and joint pain. It is commonly called "breakbone fever" because of the severity of pain. There is

virtually no mortality in classical dengue. Recovery is complete, but weakness and depression may last several weeks. Dengue is caused by a *Flavivirus* and includes 4 distinct serotypes (dengue 1, 2, 3 and 4). Recovery from infection with any 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. DHF/DSS have spread throughout Southeast Asia, Indonesia and the southwest Pacific, Latin America and the Caribbean. DHF requires exposure to 2 different serotypes, either sequentially or during a single epidemic involving more than one serotype. DHF is a severe disease that produces high mortality 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 to 40 years), mainly because the virus and its mosquito vectors were transported between population centers by sailing vessels. Dengue virus was first isolated and characterized in the 1940s. 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 throughout the war the U.S. Army experienced nearly 110,000 cases. At Espiritu Santo in the Pacific, an estimated 25% of U.S. military personnel became ill with dengue, causing a loss of 80,000 man-days. From 1942 to 1944, the incidence of dengue was 25 cases per 1,000 per annum. More recently, dengue was an important cause of febrile illness among U.S. troops during Operation Restore Hope in Somalia. A global pandemic of dengue began in Southeast Asia after World War II and has intensified during the last 15 years. Epidemics of dengue are noted for affecting large numbers of nonimmune civilians or military forces operating in an endemic area.

Dengue is the greatest arthropod-borne disease threat to military personnel operating in the Caribbean. Dengue accounted for at least 30% of febrile illness among hospitalized U.S. troops during the first 6 weeks of Operation Uphold Democracy in Haiti. From June through October 1995, dengue caused 32% of febrile illness in multinational peacekeepers deployed to Haiti. Investigation revealed low unit readiness to perform standard vector control activities and poor individual adherence to measures to prevent arthropod bites. During August 1995, a dengue incidence of 69% occurred in participants in a community-assistance program in Tortola, British Virgin Islands. Most of the aid workers rarely used insect repellents or bednets.

Disease Distribution. Worldwide, dengue is the most important mosquito-borne virus affecting humans and is present in nearly all tropical countries. Outbreaks involving 500,000 to 2 million cases have occurred in many parts of the world. Its distribution is congruent with that of its primary vector, *Aedes aegypti*, between 40° N and 40° S latitude. In recent years, dengue, especially DHF, has been expanding throughout the world. An estimated 2.5 billion people live in areas at risk for dengue transmission, and 30 to 50 million cases of dengue are reported annually.

Dengue was first recognized in the Caribbean Islands during the first half of the nineteenth century. Epidemics occurred in the region from 1826 to 1828, 1850 to 1854 and 1880. Dengue fever is present throughout the Caribbean in both endemic and epidemic form. Severe forms of dengue fever, DHF and DSS, were not prominent in the region until the 1981 epidemic in Cuba, where dengue 2 was introduced four years after an epidemic of dengue 1. Cases of DHF/DSS have subsequently been reported from the Dominican Republic, Guadeloupe, Haiti, Martinique and Puerto Rico.

Over the last 25 years, dengue serotypes 1, 2, and 4 have become endemic in the Caribbean, producing numerous epidemics at irregular intervals, although major outbreaks tend to recur in the same country every decade. In recent years, however, progressive shortening of the inter-epidemic period has been observed, with major outbreaks occurring every 1 to 5 years. After an absence of over 15 years, dengue serotype 3 has reappeared in the Caribbean (Table 1).

Table 1. Dengue serotypes identified in Caribbean countries from 1997 through 2000.

Dengue 1	Dengue 2	Dengue 3	Dengue 4
Antigua & Barbuda	Anguilla	Aruba (1999)	Bahamas
Barbados	Barbados	Barbados(1999)	Barbados
Dominica	British Virgin Islands	Dominica (2000)	Virgin Islands
Jamaica	Grenada	Guadeloupe (2000)	Jamaica
Saint Lucia	Saint Lucia	Jamaica (1998)	Trinidad & Tobago
St. Vincent	Saint Vincent	Martinique (1999)	
Trinidad & Tobago	Trinidad & Tobago	Netherlands Antilles (2000)	
		Puerto Rico (1998)	
		St. Kitts & Nevis (1998)	
		St. Martin (French side, 2000)	

The new dengue 3 strains have been shown to be genetically distinct from the dengue 3 strains previously found in the Americas. The potential for a Caribbean-wide epidemic due to the type 3 serotype is great, because an extremely high proportion of the population is immunologically virgin to this specific serotype. The emergence of dengue serotype 3 will significantly enhance the incidence of DHF/DSS in the local population. Transmission occurs year-round in coastal and lowland urban areas, although an increase in the number of cases usually follows the rainy season. Only Bermuda and the Cayman Islands have been dengue-free in recent years. During the first 3 months of 2001, at least 330 dengue cases, including 39 cases of DSS, have been reported from Trinidad and Tobago, and over 200 cases of dengue have been reported from Barbados.

Cuba. Major epidemics in Cuba during 1977 and 1978 were attributed to dengue 1. The epidemic that followed in 1981 resulted in 344,203 clinical cases, 10,312 of which were severe cases of DHF. This epidemic was caused primarily by dengue 2, although some cases of dengue 1 were reported. The next major outbreak occurred in Santiago de Cuba during 1997; 2,946 cases caused by dengue 2 were confirmed, including 205 cases of DHF and 12 deaths. Transmission continued into 1998. Risk of DHF/DSS results from sequential dengue infection of different serotypes. The Cuban experience indicates that immune enhancement leading to DHF/DSS can occur even 20 years after the primary dengue virus infection.

Dominican Republic. Dengue cases occurred every year during the 1980s and 1990s. During 1995, at least 1,700 cases, including 38 cases of DHF/DSS, were reported, and more than 1,900 dengue cases occurred during 1997. An estimated 1,800 cases occurred between 1 January and 5 September in 1998, and incidence increased later in September following Hurricane Georges.

Haiti. Numerous cases of dengue occurred among U.S. and other foreign personnel from 1994 through 1997. Before cases were confirmed in 1994, dengue fever had not been officially reported since 1985. However, this was probably due to the lack of surveillance and laboratory diagnostic capabilities in Haiti rather than absence of disease. Dengue has been shown to be underreported on islands with better public health infrastructure, such as Puerto Rico.

Puerto Rico. During 1986, Puerto Rico experienced its eleventh dengue epidemic of the century. Over 10,000 cases were reported. The island has experienced several outbreaks since then, including 4,329 confirmed cases in 1994, and 4,677 cases in 1998, of which 2,888 displayed hemorrhagic symptoms.

Transmission Cycle(s). Dengue virus is primarily associated with *Aedes* mosquitoes in the subgenus *Stegomyia*. The virus is maintained in a human-*Ae. aegypti* cycle in tropical urban areas. A monkey-mosquito cycle serves to maintain the virus in sylvatic situations in Southeast Asia and West Africa. Humans are the reservoir, and no evidence of dengue in feral Caribbean primates or natural populations of howler monkeys (*Alouatta* spp.) on Trinidad has been reported. Mosquitoes are able to transmit dengue virus 8 to 10 days after an infective blood meal and can transmit the virus for life. Dengue virus replicates rapidly in the mosquito at temperatures above 25°C. Evidence for transovarial transmission of dengue virus in *Ae. aegypti* has been demonstrated in the laboratory and field-collected mosquitoes in other parts of the world.

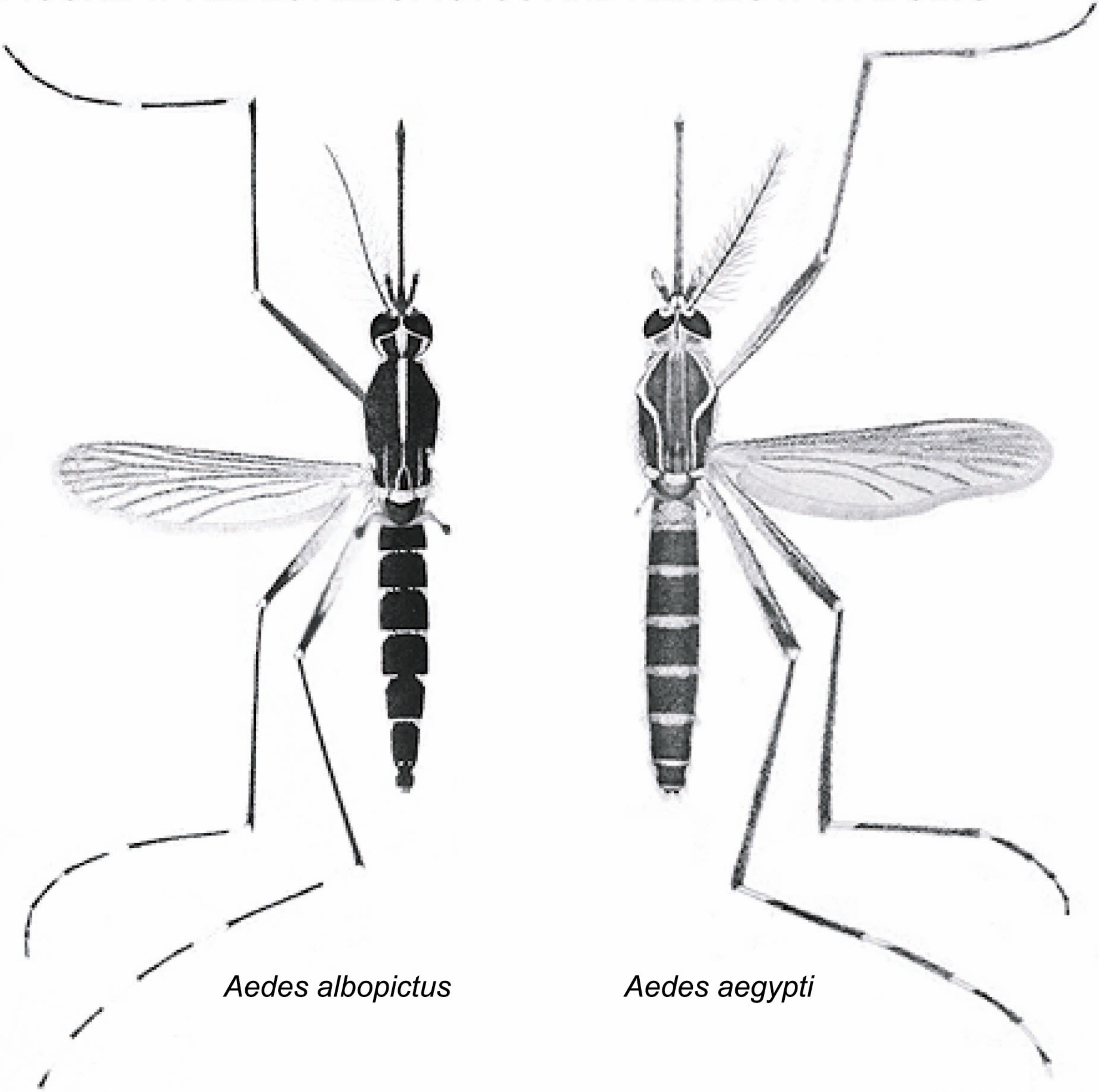
Vector Ecology Profiles. *Aedes aegypti*, the primary vector of dengue, is widespread in the Caribbean region. Between 1948 and 1972, *Ae. aegypti* was eradicated from many countries of the region, but due to inadequate surveillance against re-infestation, these countries were later infested again and suffered dengue epidemics. By 1997 all islands in the Carribean except Bermuda were infested. This species is more common in cities and 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.
Aedes aegypti deposits its eggs singly or in small groups of 2 to 20 above the water line of its habitat. A total of 100 eggs may be laid by a female utilizing many sites. Eggs may withstand dessication for 3 months or

more. Larvae emerge after eggs have been submerged for 4 or more hours, depending on the state of embryo development within the egg. *Aedes aegypti* larvae live in artificial water containers, including flowerpots, cisterns, water jugs, tires and flooded basements. The abundance of larval populations usually parallels fluctuations in rainfall, especially during and after summer monsoons that occur in some parts of the region. Occasionally, *Ae. aegypti* is reported from coconut shells or bamboo stumps, although these are more typical habitats for *Ae. albopictus*. *Aedes aegypti* has been observed breeding in rock holes on the island of Anguilla. Holes more than 100mm in diameter and about 50 mm deep that hold at least 20 mm of water serve as larval habitats. Larvae prefer relatively clean and clear water. They develop quickly in warm water, maturing to the pupal stage in about 9 days. Pupae remain active in the water container until adult emergence, 1 to 5 days after pupation. *Aedes aegypti* rarely disperses more than 50 m from its breeding site, but over several days it can disperse as far as 500 to 800 m, depending on the availability of oviposition sites. It does not fly when winds exceed 5 km per hour.

Aedes aegypti prefers human hosts and feeds primarily around human habitations. It is a diurnal feeder and readily enters homes. This species is not attracted to light; rather, 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 the movements of its host. This behavior results in multiple bloodmeals, often taken within the same dwelling, which increases transmission of the 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 among trees, shrubs, and structures.

Aedes albopictus is second only to *Ae. aegypti* in importance as a vector of dengue. The discovery of *Ae. albopictus* in Santo Domingo, Dominican Republic, in 1993 was the first report of this species in the Caribbean. It has also been reported from Barbados, the Cayman Islands, and Havana, Cuba. If this species becomes established throughout the Caribbean region, the areas at risk for dengue will significantly increase. Adults of the two species can easily be distinguished by the pattern of silver scales on the top of the thorax (Figure 4). *Aedes albopictus* is more common in rural than urban areas. Its larval and adult feeding habits are similar to those of *Ae. aegypti*, but it is more commonly found breeding in natural containers, such as tree holes, leaf axils, and fallen fruit husks.

FIGURE 4. *AEDES ALBOPICTUS* AND *AE. AEGYPTI* ADULTS



Aedes albopictus *Aedes aegypti*

It is a slightly stronger flier than *Ae. aegypti*. *Aedes albopictus* is strongly anthropophilic but has a broader host range than *Ae. aegypti* and may feed on oxen, dogs and pigs. *Aedes albopictus* does not readily feed on birds.

Aedes albopictus most often occurs in partially forested areas, particularly along forest fringes, where it may be present in large numbers. It is generally absent from the interiors of deep forests or jungles. Eggs are deposited singly or in small numbers above the water line and hatch after being flooded for 1 to 7 days, depending on the state of embryo development within the egg. Eggs may withstand desiccation for several months if not flooded. Larvae occur in manmade containers, bamboo stumps, coconut shells, tires, treeholes, and rock pools. Breeding sites are usually slightly shaded. *Aedes albopictus* is less likely to breed in indoor containers than *Ae. aegypti*. The larval development time varies from 5 days to 3 weeks, depending on temperature. Adults emerge 1 to 5 days after pupation. Females feed every 3 to 5 days for the duration of their life, which lasts from 1 to 4 weeks. Females fly close to the ground and generally not further than 100 m from their breeding sites. They do not fly in winds over several km per hour. Adults may also feed on nectar from plants. Autogeny occurs in this species, although usually only 2 to 4 eggs are produced in this manner. Peak feeding periods outdoors are generally early morning and late afternoon. Adults usually feed outdoors and rest outdoors in undergrowth. However, indoor feeding and resting behavior also occurs.

Aedes mediovittatus is widespread in Cuba, Puerto Rico, and possibly other parts of the Caribbean. Experimentally it has been shown to be an efficient vector of dengue. *Aedes mediovittatus* normally inhabits forests but has adapted to peridomestic habitats. Larvae occur in treeholes, bamboo stumps, automobile tires, vases, flower pots, cisterns and small containers, frequently sharing the same breeding sites with *Ae. aegypti*. Adults are less anthropophilic than *Ae. aegypti* and feed during the day, especially early in the morning and late in the afternoon. Transovarial transmission rates in *Aedes mediovittatus* are the highest ever documented in any species of mosquito for dengue viruses. This species may therefore play an important role in the maintenance of dengue viruses during interepidemic periods.

Vector Surveillance and Suppression. 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, usually 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 larvae. The container index is the percentage of containers in each house that have larvae. The Breteau index is more widely used and is the number of positive containers per 100 premises. There is a risk of dengue transmission when the Breteau index goes above 5, and emergency vector control is indicated when the index exceeds 100. However, a study in Trinidad concluded that all 3 indices had no correspondence with the number of *Ae. aegypti* pupae per hectare, and that pupal surveys are more appropriate for assessing the risk of transmission and directing control operations. Adult egg-laying activity can be monitored using black oviposition traps that container-breeding *Aedes* readily utilize. The number of eggs laid in the ovitraps provides a relative indication of the abundance of dengue vectors. Ovitraps are especially useful for the early detection of new infestations in areas where dengue vectors have been eliminated.

No vaccine and no specific treatment exists for dengue, so control of dengue fever is contingent upon reducing or eliminating vector populations. Ground or aerial applications of insecticidal aerosols have been relied upon to reduce adult populations during epidemics of dengue. Many vector control specialists have questioned the efficacy of ULV adulticiding. In some outbreaks of dengue fever, ULV dispersal of insecticides has had only a modest impact on adult mosquito populations. During an outbreak of dengue fever in Jamaica from October to December 1995, aerial ULV dispersal of malathion failed to reduce the oviposition rate of *Ae. aegypti* or produce significant mortality in caged adults.

Aedes aegypti is a domestic mosquito that frequently rests and feeds indoors and therefore is not readily exposed to aerosols. Lack of efficacy of adulticiding has necessitated a reevaluation of the strategies for the prevention and control of dengue. More reliance is now being placed on community-based integrated approaches to *Ae. aegypti* control, with greater reliance on larval source reduction. In 1988, the Breteau index was 54 on the small island of Liuchiu, Taiwan. After a community-based implementation of source reduction was undertaken, the Breteau index for *Ae. aegypti* declined to 1.2 by 1996.

Containers for storing potable water have been important breeding sources for *Ae. aegypti* during dengue epidemics in many parts of the Caribbean. During the mid-1990s, a survey on Trinidad found that outdoor drums, tubs, buckets, and small containers such as bottles and cans accounted for >90% of immature *Ae. aegypti*. 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 of breeding sources, such as old tires, flowerpots, and other artificial containers, is the most effective way to reduce mosquito populations and prevent dengue outbreaks. Proper disposal of trash, bottles and cans at military cantonments must be rigidly enforced. The individual soldier can best prevent infection by using **personal protective measures** during the day when vector mosquitoes are active. Wear permethrin-impregnated BDUs and use extended-duration DEET repellent on exposed skin surfaces (see TG 36).

C. Yellow Fever.

The virus that causes yellow fever belongs to the genus *Flavivirus* of the family Flaviviridae. The incubation period is 3 to 6 days after the bite of an infected mosquito, and the patient is infectious to mosquitoes for the first 3 to 4 days after onset of symptoms. Yellow fever is characterized by a sudden onset of fever, headache, general muscle pain, nausea and vomiting. Jaundice may be absent in mild cases. The pulse is slow, weak and out of proportion to the elevated body temperature (Faget's sign). Most infections resolve about the fifth day after onset of symptoms.

After a brief remission of 10 to 24 hours, some cases progress into a toxic phase with jaundice, vomiting (black vomitus), and hemorrhagic symptoms that include bleeding from the nose and gums, and blood in the urine. Shock, liver and kidney failure occur in 20 to 50% of jaundiced cases. Death usually occurs between the seventh and tenth day after onset of symptoms. Person- to-person transmission does not occur. The case fatality rate among indigenous populations in endemic regions is about 5% but may reach 20 to 40% during some outbreaks. Recovery from yellow fever results in long-lasting immunity against reinfection.

Military Impact and Historical Perspective. Yellow fever originated in Africa and was brought to the New World by West African slaves in the seventeenth century. The first clinical report on yellow fever was published in 1778, based on observations during an outbreak in Senegal. For more than 200 years the tropical and subtropical Americas were subject to devastating epidemics. Serious outbreaks occurred as far north as New York and Boston and as far away from endemic areas as Spain, France, England and Italy. Yellow fever appeared in the Caribbean islands by 1620 and epidemics repeatedly swept over the West Indies, Central America and the southern U.S., paralyzing industry and trade. Yellow fever was one of the most dreaded diseases of the Atlantic trade routes. The entire crew of a ship usually perished if an infection occurred onboard, since no port would give harbor to an infected vessel.

Epidemics frequently occurred in garrisons of troops newly arrived in the Caribbean islands, producing mortality as high as 80%. Ships carried yellow fever and its vector from island to island. The disease plagued the Caribbean until the end of the nineteenth century. In 1741, the British lost 20,000 of 27,000 men to an epidemic of "black vomit" during an attempt to conquer Mexico and Peru. The French in 1802 lost 29,000 of 33,000 men to yellow fever while attempting to acquire Haiti and the Mississippi Valley, which contributed to their decision to sell the vast area bought by the U.S. in the Louisiana Purchase. Yellow fever and malaria were important factors influencing the French to stop construction of the Panama Canal. During the Spanish-American War, yellow fever epidemics in the American army in Cuba led U.S. authorities to appoint a yellow fever commission with Walter Reed, an army surgeon, as its head. Reed and his coworkers discovered the cause of the disease and demonstrated that the spread of yellow fever could be controlled by anti-mosquito measures and protection of the sick from mosquito bites. The conclusions of the commission were put into practice by William Gorgas, who eradicated yellow fever from Cuba and Panama in 1900.

Yellow fever is not a threat to military personnel in the Caribbean due to the low enzootic prevalence of the disease, which may circulate only in forested areas of Trinidad, and the availability of an effective vaccine that provides complete protection against infection with the yellow fever virus.

Disease Distribution. Sylvatic transmission of yellow fever is restricted to tropical and subtropical areas of Africa and Latin America, where a few hundred cases are reported annually, usually among young males who are occupationally exposed in forested areas. Some public health authorities believe the annual number of cases is much higher due to underreporting and the lack of vaccination programs in many African nations.

During the 1990s, only 6 Latin American countries reported yellow fever: Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela. The disease occurred primarily in unvaccinated people who entered the forest for hunting, fishing or wood cutting and became infected from the sylvatic cycle. With the exception of a few cases in Trinidad during 1954, no outbreak of urban yellow fever has occurred since 1942 in the Caribbean. However, during 1998 there was a yellow fever outbreak in nearby Venezuela.

From 1901 to 1950, urban yellow fever was brought under control in the Caribbean. During the period from 1901 to 1922, 985 cases of yellow fever were reported from the Caribbean islands, but the disease was not reported from 1923 to 1950, although cases of yellow fever continued to occur in many countries of South America. An outbreak of yellow fever occurred in 1954 in Trinidad, and yellow fever virus was isolated from humans, howler monkeys and *Haemagogus* mosquitoes. In 1979, 18 human cases of sylvatic yellow fever occurred in Trinidad. Cases were initially detected in the Trinity Hills area. Following the outbreak, 80% of the population over 1 year of age were vaccinated. A yellow fever vaccination is not required for entry into Trinidad and Tobago, except for travelers coming from areas designated by WHO as currently infected with yellow fever.

There is no evidence of yellow fever activity on the island of Tobago. Yellow fever virus has never been isolated from *Ae. aegypti* or other species of mosquitoes in Tobago, and the monkeys associated with sylvatic yellow fever are not found there as they are on Trinidad. Current distribution of yellow fever in the Caribbean is depicted in Figure 5.

Transmission Cycle(s). Two epidemiological cycles occur in South America. In urban areas, yellow fever virus is transmitted between humans by *Aedes aegypti*, with humans acting as the amplifying host. In forested areas, a jungle or sylvatic cycle of transmission occurs between *Haemagogus* mosquitoes, monkeys and possibly marsupials. The sylvatic cycle is considerably more complex in Africa. Yellow fever transmission increases during the rainy season due to increased populations of mosquitoes. Forestry practices, such as felling trees, increase transmission of sylvatic yellow fever by bringing treetop-dwelling mosquitoes down to ground level where they can bite humans. Transovarial transmission has been demonstrated in *Aedes* and *Haemagogus* mosquitoes, and many researchers now believe that mosquito vectors may be the true reservoir of the yellow fever virus. The mechanisms underlying the periodic occurrence of epizootic yellow fever activity in Trinidad are not fully

FIG. 5. POTENTIAL ENDEMIC AREA OF YELLOW FEVER IN THE CARIBBEAN (SHADED AREA).

understood. It is unknown whether the virus is periodically reintroduced from enzootic areas of South America or is maintained in the forests of Trinidad between outbreaks. Yellow fever virus has been isolated from howler monkeys (*Alouatta* spp.) during epizootics and epidemics in Trinidad.

Vector Ecology Profiles. *Aedes aegypti* is the primary if not sole vector of urban yellow fever throughout the Caribbean and Latin America. The virus is found in the salivary glands 12 to 15 days after an infective blood meal, and adult mosquitoes remain infective for life. Intensive eradication programs eliminated urban yellow fever from the Caribbean and Latin America by the 1950s. *Aedes aegypti* was eradicated from Brazil in 1954 but had reappeared by 1976. *Aedes aegypti* has reinfested nearly all of the Americas and the Caribbean due to a lack of well-funded and organized surveillance and control programs. The introduction of

Ae. albopictus into the Americas as well as the Caribbean may also increase the risk of future outbreaks of urban yellow fever. *Aedes albopictus* could serve as an important bridge vector between sylvatic and urban cycles of the virus. The bionomics of both species is discussed under dengue.

Haemagogus mosquitoes are the primary sylvatic vectors of yellow fever. Adults have distinctive flat, metallic green or blue scales that are visible even under a hand lens. Numerous isolations of yellow fever virus have been made from *Haemagogus janthinomys* in Trinidad. This is a primary vector of sylvatic yellow fever in South America. Eggs are laid above the water line in tree holes and rock holes and hatch when flooded. Eggs can remain viable for many months. Sometimes multiple flooding and desiccation cycles are required to induce hatching. Populations of *Ha. janthinomys* are about 6 times higher during the rainy season (May through November) than the dry season (December through April). Adults of some *Haemagogus* spp. do not fly far from their breeding sites in the tree canopy, where they feed on monkeys. However, *Ha. janthinomys* will readily leave the tree canopy and feed at ground level on forest ruminants and humans. If the forest is cut, this species can survive at ground level in plantations and will bite humans. Adults feed during the day between 0600 and 1800 hrs, with a single peak of activity between 1000 and 1600 hrs. *Haemagogus janthinomys* usually feeds on the lower limbs and feet of humans. Adult females can survive 2 to 3 months in the laboratory, although survival rates in nature are much lower.

Haemagogus leucocelaenus is another common vector of sylvatic yellow fever in Trinidad as well as South America. Its biology is similar to *Haemagogus janthinomys*. Adults are active from 0600 and 1800 hrs, with a single peak of activity between 1000 and 1400 hours. Populations also peak during the rainy season. It will feed on humans at ground level. This species has been found breeding in artificial containers in Brazil.

Haemagogus equinus is only occasionally collected in Trinidad and shares a similar ecology with *Haemagogus janthinomys*. It is an important sylvatic vector in Guatemala. In addition to tree holes, it breeds in tires and artificial containers in Colombia and Trinidad. *Haemagogus splendens* has been reported from St. Vincent and the Grenadines.

Haemagogus janthinomys, *Ha. equinus*, and *Ha. celeste* have been collected from Monos, Huevos, Chacachacare and Gaspar Grande islands off the northwestern peninsula of Trinidad. On Monos Island, *Ha. janthinomys* was found breeding in a rock hole. *Haemagogus celeste* has been shown to transmit yellow fever virus in the laboratory but is not known as a vector in the field.

Occasional isolations of yellow fever virus have been made from *Sabethes chloropterus* during epizootics of sylvatic yellow fever in Trinidad. This species is a sylvatic vector in South America, where it breeds in tree holes and bamboo stems. Like *Haemagogus* spp., it frequently rests in tree holes. Adults feed primarily on monkeys in the forest canopy but will also bite humans, often on the face and ears. This species is less likely to feed at ground level and was most commonly found at 12 m in a South American study. *Sabethes chloropterus* is highly tolerant of arid conditions, but populations peak in Trinidad by the middle of the rainy season (July through October). Adults are diurnal and exhibit a unimodal peak of activity during the wet season, chiefly between 1200 and 1600 hrs. Diurnal activity during the dry season is bimodal, with peaks at 0800 to 1000 hours and 1200 to 1400 hrs.

Vector Surveillance and Suppression. The discovery that forest monkeys were involved in a sylvatic cycle of yellow fever virus dimmed all hopes that yellow fever could be eradicated from the Western Hemisphere. Control of sylvatic vectors high in the forest canopy is impractical. Even aerial dispersal of ULV aerosols will not penetrate double- and triple-layered canopies.

Oviposition traps are used to measure the seasonal and vertical distribution of *Sabethes* and *Haemagogus* mosquitoes. The surveillance and control of *Ae. aegypti* and *Ae. albopictus* are discussed under dengue.

The death of forest monkeys, particularly howler monkeys (*Alouatta* spp.) and spider monkeys (*Ateles* spp.), may indicate an epizootic of sylvatic yellow fever, which often precedes human cases.

Mass vaccination of the human population has been used to stop and prevent epidemics. The yellow fever vaccine is safe and provides at least 10 years of protection.

D. Eastern Equine Encephalitis.

Eastern Equine Encephalitis (EEE) is caused by an *Alphavirus* in the family Togaviridae and is closely related to western and Venezuelan equine encephalitis viruses. The EEE virus is divided into North and South American antigenic varieties based on serological tests. EEE is a very serious disease, producing mortality rates up to 70% and disabling neurological sequelae in at least 30% of those who recover, especially children and the elderly. The incubation period is usually 5 to 15 days. Onset is abrupt and characterized by muscle and joint pain. A patient may experience severe muscular shaking that lasts for a few days. The illness lasts for 1 to 2 weeks. If there is no central nervous system involvement, recovery is complete. Infection can progress to nervous irritability, headache, vomiting, diarrhea, convulsions, coma and death from encephalitis. Death typically occurs 2 to 10 days after onset of symptoms. Transmission of EEE virus from person to person does not occur.

Military Impact and Historical Perspective. EEE virus has been the cause of epizootics in North American horses at least since 1831, but undoubtedly the virus was present long before then. It was not isolated until a 1933 outbreak in horses in coastal areas of the mid-Atlantic states. The first human cases were confirmed in 1938 by virus isolation from brain tissue in New England. The severe pathology produced by EEE virus is a serious medical concern to military personnel operating in enzootic areas. There is neither a licensed vaccine for human use nor an effective therapeutic drug. Cost of medical support ranges from $21,000 for transiently infected individuals to $3 million for neurologically impaired patients. Fortunately, outbreaks of EEE in civilian populations have involved relatively small numbers of cases. The incidence of infection could be higher during military operations due to greater exposure to potential vectors.

Disease Distribution. EEE occurs principally along the east and Gulf coasts of the U.S., in the north-central U.S. and adjacent Canada, and in scattered areas in Central and South America and the Caribbean islands. Outbreaks of EEE are infrequent and unpredictable. There have been 153 confirmed cases in the U.S. since 1964. Sporadic epizootics in horses and occasional human cases have occurred on several Caribbean islands. During the 1950s and early 1960s, numerous isolations of EEE virus were made from mosquitoes, birds, sentinel mice and horses in Trinidad, although confirmed human cases were rare. The EEE viral strains isolated in Trinidad were antigenically similar to the South American subtype EEE virus. During 1962, an outbreak of EEE occurred in Jamaica's eastern province of St. Thomas involving horses and 11 human cases, including 9 deaths. During 1978, an epizootic occurred in horses from 2 provinces (María Trinidad Sánchez and Samaná) in the Dominican Republic. Enzootic EEE likely exists in Haiti, but this has not been confirmed. Periodic epizootics lasting several months and causing high mortality in horses with occasional human cases occurred in Cuba until 1968. From 1969 to 1972, Cuban EEE epizootics were characterized by short duration, low equine mortality and no human cases. No further cases have been reported since 1973. Virological and serological surveys of wild vertebrates in Cuba demonstrated that birds are definitely the main hosts of EEE virus, although the virus was also isolated from iguanas. Survey results suggest that in Cuba there are at least 2 types of EEE foci: 1) forest and 2) water-littoral (freshwater swamps and lakes, and seacoasts with mangrove forests). Strains of EEE virus isolated from Jamaica, the Dominican Republic and Cuba have been North American subtypes.

Transmission Cycle(s). Despite decades of field studies, the epidemiology of EEE is poorly understood. EEE virus is believed to circulate in isolated foci of swamps and wetlands within communities of arthropod vectors and vertebrate hosts. Each year epizootic activity may occur in a different location or several different locations, rather than being widespread. The primary reservoir hosts are birds, especially passerine birds, and the primary epizootic vector(s) are ornithophilic mosquitoes. In eastern swamps and wetlands of the U.S., *Culiseta melanura* is the primary epizootic vector. At some point in this cycle, other mosquitoes that have a broader host range become involved as secondary vectors. These bridge vectors may in turn infect small mammals, domestic fowl, equines and humans. An influx of migratory birds could also contribute to EEE epidemics.

A wide variety of animals have been found naturally infected with EEE virus, including many species of small mammals, woodchucks, rabbits, bats and even some reptiles and amphibians. Most songbirds are not adversely affected by EEE viral infection, although domestic birds such as chickens, turkeys, pheasants and ducks may become ill and die. In Jamaica, studies suggest that domestic chickens may act as reservoirs or amplifying hosts for the virus. In the U.S., EEE outbreaks in horses or humans have usually occurred within a few miles of swamps or wetlands. The prevalence of EEE viral antibody in birds decreases with distance from known swamp foci. Humans are a dead-end host and do not develop sufficient viremia to infect mosquitoes. It is generally believed that equines are also dead-end hosts, yet experimental studies have shown viremias high enough to infect mosquitoes, and thus horses may enter into the epidemic maintenance of EEE virus. The overwintering mechanisms of the virus in temperate climates and the mechanisms of survival between epizootic outbreaks in tropical climates are not known.

Vector Ecology Profiles. Isolation of EEE virus from mosquitoes is very common during epizootics and epidemics, but much less common during inter-epizootic periods. Isolations have been reported from at least 30 species of mosquitoes, most of which remain infected for life.

Eastern equine encephalitis (EEE) virus has been isolated from *Culex nigripalpus* in the Dominican Republic and from *Cx. taeniopus* and *Cx. portesi* in Trinidad. *Ochlerotatus taeniorhynchus* is a secondary vector of EEE and occurs throughout the Caribbean region. *Culex nigripalpus* is widespread in the Lesser Antilles, Jamaica, Haiti, the Dominican Republic, and Cuba. *Culex taeniopus* is a potential vector in Jamaica and the Cayman Islands. *Culex* mosquitoes feed primarily at night and during the twilight periods of dusk and dawn.

In Jamaica, populations of *Cx. nigripalpus* increase rapidly in November during the early part of the rainy season and reach a peak between February and April at the end of the rainy season. This species is common along the coastal plains of many Caribbean islands. Larvae of *Cx. nigripalpus* breed in diverse habitats, including foul water, tire ruts and other temporary pools, ditches, marshy pools, swamps and lake margins. They also occur in leaf axils, tree holes and artificial containers. Utilization of a wide variety of breeding habitats close to urban and suburban areas enhances this species' ability to transmit EEE and St. Louis encephalitis viruses. This mosquito is primarily exophilic, occurs in large numbers in forested areas, and is attracted to lights. *Culex nigripalpus* feeds primarily on birds but will readily bite large domestic mammals and humans.

Eggs of *Culex taeniopus* are peculiarly curved and are deposited on damp surfaces in small clusters. They are significantly more resistant to desiccation than the eggs of most other *Culex* species. Larvae occur in crabholes, sluggish streams, and isolated ground pools of fast-moving streams. Adults are exophilic and occur in relatively large numbers, but they are not as abundant as *Cx. nigripalpus*. They readily feed on humans and mammals such as opossums, rodents and rabbits. *Culex taeniopus* also feeds on birds and may be a bridge vector from the enzootic foci of EEE virus to equines and humans. Adults are attracted to lights.

In Trinidad, *Cx. portesi* feeds on relatively insensitive marsupials with long tails, primarily opossums in the genera *Didelphis*, *Marmosa* and *Caluromys*. This mosquito is also attracted to reptiles. During field studies, *Culex portesi* showed higher engorgement rates than *Cx. taeniopus*, suggesting a more aggressive feeding behavior.

Ochlerotatus (formerly *Aedes*) *taeniorhynchus,* the black salt-marsh mosquito, occurs primarily in coastal salt and brackish marshes. Populations peak during periods of high tides and intense rains. Larvae can complete development in as few as four days and adults may emerge only 8 to 10 days after oviposition. Broods of adults often emerge synchronously every two to three weeks. This mosquito is one of the most abundant species in the region, particularly in Cuba. Females are persistent biters, attacking from their resting spots in dense vegetation by day or night. They are strong fliers and will disperse en masse many miles if hosts are not available locally. This species, while primarily exophilic, will enter houses and feed on humans; however, it is primarily a zoophilic species. Laboratory studies have shown *O. taeniorhynchus* to be competent vector of EEE virus, and the long flight range of this species is important in disseminating EEE virus from foci in wetlands.

Mosquitoes that are opportunistic feeders, feeding equally on birds or mammals, are ideal epizootic and epidemic vectors. *Aedes albopictus* is highly susceptible to EEE virus in the laboratory and has been found naturally infected in Florida. If *Ae. albopictus* becomes widespread in the Caribbean, this species could function as an important bridge vector between the enzootic avian cycle and susceptible mammalian hosts.

Vector Surveillance and Suppression. In addition to viral isolations from passerine birds and mosquitoes, seroconversion in sentinel chickens is commonly used to monitor EEE virus activity. Pheasants have been demonstrated to be better sentinel hosts than chickens for EEE virus. During epizootics, mass vaccination of equines is conducted by veterinarians. These techniques are time consuming, costly, require specialized personnel and laboratory capabilities, and are generally impractical during military operations. The adults of most *Culex* spp. can be collected in light traps or light traps supplemented with carbon dioxide. A number of traps have been designed to collect gravid females seeking a place to deposit eggs. **Personal protective measures**, discussed in TG 36, afford the best protection against EEE and other arthropod-borne diseases. Application of ULV aerosols to reduce adult mosquito populations during epizootics may help interrupt transmission of EEE virus.

E. St. Louis Encephalitis.

The virus causing St. Louis encephalitis (SLE) is a *Flavivirus* in the family Flaviviridae. Close antigenic relationships exist between SLE virus, Japanese encephalitis virus and West Nile virus. SLE is principally a central nervous system disease in humans. A wide range of clinical manifestations occur, from inapparent infection to death from encephalitis. The majority of infections are asymptomatic, and several hundred inapparent infections occur for each symptomatic case. Increasing severity of illness is associated with advancing age, and most cases in the elderly lead to encephalitis, with case fatality rates as high as 30%. Clinical symptoms include fever, headache, dizziness, nausea and malaise. Symptoms may intensify over a period of several days to 1 week, leading to complete recovery in most cases. In severe cases central nervous system infection may develop progressively, leading to encephalitis, coma and death. No vaccine or specific therapy is available.

Military Impact and Historical Perspective. SLE virus was isolated from a human brain in 1933 when a large outbreak of the disease occurred in St. Louis, MO. Since this first recognition of SLE, the occurrence of the disease in North America has been characterized by periodic outbreaks that interrupt years of minimal endemic transmission. In the U.S., epidemics have frequently occurred in large cities, although smaller towns have been the principal foci in some outbreaks. Only sporadic cases of SLE have occurred in the Caribbean, and the disease appears to present little risk to military personnel operating in the region.

Disease Distribution. The geographic range of SLE virus extends from Canada to Argentina; however, human cases have occurred almost exclusively in the U.S., especially in central and eastern states. During the 1990s, outbreaks of SLE occurred in Florida. In the Caribbean, sporadic human cases of SLE have occurred only in Jamaica and Trinidad. The Trinidad isolates of 1955 were the first SLE strains to be isolated south of the continental U.S. Transmission can occur year-round in the Caribbean, although risk of transmission is higher during the rainy season. Serological surveys of humans and birds indicate that SLE virus is or has been widely distributed in Jamaica.

Transmission Cycle(s). In the U.S., SLE virus is cycled primarily between *Culex* (subgenus *Culex*) mosquitoes and songbirds (passeriforms) or doves and pigeons (columbiforms). Infection in these birds is inapparent. Chickens, especially young chickens, may be important amplifying hosts in some enzootic areas. A wide variety of mammals have been found naturally infected, including raccoons, opossums, rodents and bats. Viremia in these hosts is usually too low to infect mosquitoes, and they probably do not contribute to the basic transmission cycle of SLE virus. Infection in equines is usually asymptomatic. Transmission cycles of SLE virus in the Caribbean and in Central and South America have not been elucidated, although SLE virus has been isolated from birds in Jamaica and Trinidad.

Vector Ecology Profiles. SLE virus has been isolated from a wide variety of naturally infected mosquitoes, though many species that are capable of transmitting the virus in the laboratory have not been incriminated as vectors in field studies. *Culex pipiens* and *Cx. quinquefasciatus* are important vectors in many parts of the U.S. Strains of *Cx. quinquefasciatus* from Trinidad have been shown to be capable of transmitting SLE virus, and this species is abundant in the Caribbean. *Culex nigripalpus* is the primary vector of SLE virus in Florida and in Jamaica. SLE has been isolated from 9 species of mosquitoes in Trinidad, and an enzootic cycle between birds and forest mosquitoes may exist there. Laboratory studies indicate that *Aedes albopictus* and *Ae. bahamensis* would not be efficient vectors of SLE virus. However, evidence of transovarial transmission of SLE virus has been demonstrated primarily in *Aedes* spp., such as *Ae. bahamensis*, though the role this plays in the maintenance of virus in enzootic areas is unknown.
Vector Surveillance and Suppression. See Eastern equine encephalitis.

F. Venezuelan Equine Encephalitis (VEE).
The infectious agent of VEE is an alphavirus (*Alphavirus*, Togaviridae). Genetic relationships among viruses defining the VEE antigenic serogroup are complex. There are at least 6 subtypes and many genotypes within each subtype. Natural or laboratory acquired infections of humans have been documented with most of the epizootic and the enzootic subtypes of VEE.

Clinical manifestations of infection are influenza-like with abrupt onset of severe headache, chills, fever, muscle pain, nausea and vomiting. Most infections are relatively mild, with symptoms lasting 3 to 5 days. Central nervous system involvement is most likely to occur in children or young adults and can result in encephalitis, convulsions, paralysis, coma and death. Fatalities occur in less than 1% of clinical cases. Fetal deaths and abortions may occur in infected pregnant women. Immunological studies indicate that human infection may result in lifelong immunity.

Military Impact and Historical Perspective. In 1936 a virus was isolated from the brain of an infected horse during an outbreak of fatal equine encephalomyelitis on the Guajira Peninsula of Venezuela. The virus was shown to be different from 2 North American viral encephalitides, so the new pathogen was named Venezuelan equine encephalomyelitis. Additional studies indicated that epizootic VEE had been occurring in northern South America since the 1920s. Initial reports of human infections with VEE virus and illness in the Caribbean were from Trinidad. From 1955 to 1959, major epizootics occurred in equines in Colombia, Venezuela and Peru. Extensive epizootic activity began again in 1962 and by 1969 had spread from Colombia and Venezuela to Peru and Ecuador and into Central America. During 1969, the VEE epizootic eventually involved equines and humans in all countries in Central America except Panama, Mexico and the U.S. (Texas). During 1995, an outbreak of VEE began in northwestern Venezuela and spread westward to the Guajira Peninsula and to Colombia, where it caused an estimated 75,000 human cases, including 3,000 with neurologic complications and 300 fatalities. This was the first Colombian outbreak of VEE in 22 years and resulted in the infection of over 50,000 equines. A large outbreak of epizootic VEE occurred in the same regions of Colombia and Venezuela from 1962 to 1964.

VEE has epidemic potential when nonimmunes enter an enzootic area, although its short duration and mild febrile illness would limit any military impact. U.S. military personnel have developed clinical symptoms during military exercises in Panama.

Disease Distribution. VEE is enzootic in South and Central America, Mexico and the Florida Everglades. In the Caribbean it has been reported primarily from Trinidad, particularly the Bush Bush Forest. No recent human cases have occurred in Trinidad, although a probable case of VEE was reported in a patient in Guadeloupe during 1995. VEE has also been reported from Cuba, Barbados and St. Vincent. Extensive epizootics occur principally during the rainy season in northern and western South America.

Transmission Cycle(s). Strains of VEE can be grouped epidemiologically into enzootic strains that cause sporadic human disease and are not associated with disease among equines, and epizootic strains that cause high morbidity and mortality in equine species as well as epidemics in human populations. The enzootic cycle appears to involve transmission to small rodents and birds, especially water birds, by mosquitoes. Other small mammals, such as marsupials and sloths, may become infected. The three most common rodent species in the Bush Bush Forest of Trinidad are forest spiny pocket mice (*Heteromys anomalus*), rice rats (*Oryzomys laticeps*) and cane mice (*Zygodontomys brevicauda*). Incidence of human infection with enzootic strains of VEE virus is highly focal.

Epizootic strains of VEE virus are believed to arise naturally from minor variants of enzootic strains that circulate in lowland tropical forests. Experimental studies have shown that cattle, swine and dogs can be infected by epizootic strains and, like humans, they develop viremias high enough to infect some species of mosquitoes. However, it is unlikely that these hosts or humans play a significant role in epizootic outbreaks of VEE. Equines are considered to be the primary amplifiers of epizootic VEE virus activity. Humans are usually infected by mosquitoes that acquire their infection from equines. Human infections typically follow outbreaks in horses by approximately 2 weeks. Epizootics can move vast distances in extremely short periods of time. Laboratory infection of humans by aerosol transmission is possible, but there is no evidence of direct transmission from horses to humans. Epizootic VEE virus has been isolated from vampire bats, but their role in the transmission of this virus is not known.

Vector Ecology Profiles. At least 45 species of mosquitoes from 11 genera have been incriminated in the transmission of VEE virus. Species in the genus *Culex* (subgenus *Melanoconium*) appear to be primary vectors in addition to *Mansonia* and *Psorophora* species. In inland and coastal areas with brackish water habitats, *Ochlerotatus* (formerly *Aedes*) *taeniorhynchus* and *Ochlerotatus* (formerly *Aedes*) *sollicitans* are important vectors. *Ochlerotatus taeniorhynchus* was a primary vector during the 1995 epidemic in Colombia. *Aedes aegypti* and *Ae. albopictus* have been shown to be competent vectors of VEE virus in laboratory studies. *Aedes aegypti* is widely distributed in most urban areas of Latin America and the Caribbean. The discovery of *Aedes albopictus* in Santo Domingo, Dominican Republic, in 1993 was the first report of this species in the Caribbean. The bionomics of these 2 species is discussed under dengue. *Mansonia titillans* was incriminated as the primary mosquito vector during the 1943 epizootic in Trinidad. However, 277 isolates of VEE virus were made from 17 mosquito species during intensive studies in Trinidad from 1959 through 1964. *Culex portesi* showed the highest infection rate, though *Cx. taeniopus* and *Cx. vomerifer* were considered potentially important vectors.

Culex (*Melanoconion*) *portesi* breeds in swamp-forest ground pools and animal burrows. The larval stage of this species lasts 14 to16 days. *Culex portesi* feeds primarily on rodents but also on oppossums and the diurnal squirrel. Eggs are deposited in rafts on the water surface 4 to 5 days after a bloodmeal. In Trinidad, adult populations peak in the wet season (June to December), especially from June to July and again from October to December.

Vector Surveillance and Suppression. A vaccine for equines against VEE virus is commercially available, although evidence indicates that available vaccines may not be fully effective against all strains. The emergence of new epizootic VEE viruses is likely to continue because of the high mutation rate of these RNA viruses. Incompletely inactivated vaccines have also been implicated as a source of epizootics in the 1960s and 1970s. Investigational live attenuated virus and inactivated virus vaccines have been used to protect laboratory workers and other adults at high risk (available from the U.S. Army Medical Research and Materiel Command, Fort Detrick, MD). Control of past epizootics has been achieved by immunizing equines in affected areas and restricting their movements from the affected area, combined with control of adult mosquitoes using ULV aerosols. These measures may not be practical in most military contingency situations. Consequently, military personnel must depend on the **personal protective measures** outlined in TG 36.

G. Boutonneuse Fever. (Mediterranean tick fever, Mediterranean spotted fever, Marseilles fever, African tick typhus, Kenya tick typhus, India tick typhus)
This tick-borne typhus is a mild to severe illness lasting a few days to 2 weeks. Clinical symptoms begin 6 to 10 days after the bite of an infected tick and include fever, headache and muscle pain. A generalized maculopapular rash usually involving the palms and soles appears about the fourth to fifth day and lasts for 6 to 7 days. Boutonneuse fever is caused by *Rickettsia conorii* and closely related rickettsial organisms. Different strains of *R. conorii* isolated from ticks and humans indicate that this pathogen has substantial

genetic and antigenic diversity. The common name of this disease comes from the button-like lesions, 2 to 5 mm in diameter, that develop at tick attachment sites. With antibiotic treatment, fever lasts no more than 2 days. The case fatality rate is usually very low, even without treatment.

African tick bite fever caused by *Rickettsia africae* is clinically similar to Boutonneuse fever, except that diffuse rash is inapparent and frequently absent. Multiple lesions or eschars and swelling at the site of the tick bite are more commonly seen with African tick bite fever.

Military Impact and Historical Perspective. Historically, boutonneuse fever has not significantly interfered with military operations. Sporadic cases among combat troops can be expected in limited geographic areas. The severity of illness is dependent upon the strain of *R. conorii* contracted. Because the spotted fevers are regional diseases involving different species or strains of *Rickettsia*, military medical personnel newly assigned to an area may be unfamiliar with them, and diagnosis may be delayed. This disease would be insignificant to military personnel due to its limited prevalence in the Caribbean.

Disease Distribution. Boutonneuse fever is widespread in countries bordering the Mediterranean, and most countries of Africa. Along the European Mediterranean coast, the seroprevalence of boutonneuse fever in humans varies from 4.2 to 45.3%, depending on the area. Expansion of the European endemic zone to the north is occurring because North European tourists vacation along the Mediterranean with their dogs, which acquire infected ticks that are then brought home. Very few isolations of *R. conorii* have been reported from Caribbean countries. African tick bite fever was known only from sub-Saharan Africa until *R. africae* was isolated from the tropical bont tick, *Amblyomma variegatum*, collected on Guadeloupe in the French West Indies during 1999. A high seroprevalence of antibodies to *R. africae* was also demonstrated in humans, cattle and goats tested on the island. A French patient was recently diagnosed with African tick bite fever after a visit to Guadeloupe.

Transmission cycle(s). The disease is maintained in nature by transovarial passage of rickettsiae in ticks, primarily the brown dog tick, *Rhipicephalus sanguineus*, in the case of *R. conorii* or the tropical bont tick, *Amblyomma variegatum*, in the case of African tick bite fever. Enzootic infection in dogs, rodents, hares and other animals is usually subclinical. Dogs do not sustain infection for long but are significant because they bring ticks into close contact with people. Transmission to humans is by the bite of infected ticks. Contamination of breaks in the skin, mucous membranes, or eyes with crushed tissues or feces of infected ticks can also lead to infection. Close association with domestic dogs in endemic areas is a risk factor for boutonneuse fever.

Vector Ecology Profiles. Almost any ixodid tick may harbor the pathogen, and many are important only as zoonotic vectors.

Rhipicephalus sanguineus, the brown dog tick, occurs throughout the entire region below 50° N latitude. This tick feeds primarily on dogs but also on horses, sheep, and, occasionally, humans. It is a three-host tick, with larval and nymphal stages preferring to feed on rats or dogs, while adults feed primarily on dogs, and opportunistically on humans. Larvae and nymphs of *R. sanguineus* spend 3 to 6 days feeding on a host, then drop off to molt. Immature stages prefer the long hair at the back of the neck, while adults are commonly found in the ears and between the toes of dogs. After mating on the host animal, the female feeds for 7 to 15 days, then drops off the host to lay eggs. Females lay hundreds of eggs, generally in the dens of host animals, usually canines, or in the cracks and crevices of infested houses. Eggs may require 10 to 20 days to hatch. Adult *R. sanguineus* are passive in their host-questing activity, rarely moving more than 2 m to find a host. This species requires a humid microhabitat, which it can often find in the dens of its hosts.

Amblyomma variegatum, a three-host tick, was introduced during the mid-1950s and occurs on Puerto Rico, Antigua, Guadeloupe, Martinique and possibly other islands of the Lesser Antilles. Larvae of this tick sometimes parasitize mongooses, and have been found on ground-dwelling birds, chickens, and Carib grackles, *Quiscalus lugubris*. Cattle egrets, *Bubulcus ibis*, are frequently infested by immatures of *A. variegatum* and are believed to disseminate ticks between islands. All stages of this tick are usually found on goats, cattle, horses, sheep and pigs, with a strong preference for cattle. Each stage remains attached to the host during a 3 to10 day feeding period, then drops off to molt to the next stage. Larvae tend to be most abundant during the middle of the wet season (September to October), while nymphs appear to be more abundant at the beginning of the wet season (May to early June). Larvae require shorter feeding times (3 to 5 days) than adults, which may require 6 to 10 days.

Female ticks feed and then begin egg deposition a few days after leaving the host. The number of eggs laid is variable but may exceed 10,000. Females die shortly after oviposition is completed. Newly emerged larvae are commonly found questing for a host on vegetation along animal trails. Under ideal conditions the life cycle requires one year to complete.

Vector Surveillance and Suppression. Personal protective measures (see TG 36) afford the best protection against boutonneuse fever and other tick-borne rickettsiae of the spotted fever group. Clothing impregnated with permethrin is particularly effective against crawling arthropods like ticks. Frequent body checks while operating in tick-infested habitat are essential. Tick attachment for several hours is required for transmission of many tick-borne pathogens, so early removal of ticks can prevent infection (see Appendix E). In endemic areas, domestic dogs are commonly infested with the brown dog tick. Troops should not be allowed to feed, befriend or adopt local dogs as pets.

There are several methods that can be used to determine the numbers and species of ticks in a given area. These include dragging a piece of flannel cloth over vegetation where ticks are waiting for a passing host and collecting the ticks that attach to the cloth, collecting ticks from animal hosts or their burrows/nests, attracting ticks to a trap using carbon dioxide (usually in the form of dry ice), and removing ticks from a person walking in a prescribed area. Different species and life stages of ticks are collected disproportionately by the various methods, and techniques selected must be tailored to the species and life stage desired. These collection procedures are discussed thoroughly in TG 26, Tick-borne Diseases: Vector Surveillance and Control.

Habitat modification can reduce tick abundance in limited areas. Mechanical removal of leaf litter, underbrush, and low-growing vegetation reduces the density of small mammal hosts and deprives ixodid ticks of the structural support they need to contact hosts. Leaf litter also provides microhabitats with environmental conditions suitable for tick survival, such as high relative humidity. Controlled burning, where environmentally acceptable, has been shown to reduce tick populations for 6 to 12 months.

Large-scale application of pesticides to control ticks is usually impractical and may be environmentally unacceptable on military installations during peacetime. Chemical treatment should be confined to intensely used areas with a high risk of tick-borne disease. Liquid formulations of pesticides can be applied to vegetation at various heights to provide immediate reduction in tick populations. Granular formulations provide slower control and only affect ticks at ground level. Both formulations give approximately the same level of control when evaluated over a period of several weeks. Consult TG 24, Contingency Pest Management Guide, and TG 26, Tick-borne Diseases: Vector Surveillance and Control, for specific pesticide recommendations and application techniques.

Programs to eradicate the tropical bont tick from the Caribbean have been attempted since the 1960s with varying degrees of success. The Caribbean Amblyomma Program was established to eradicate *A. variegatum* from the region, and field activities were initiated in May 1995. Farmers and livestock owners are responsible for the compulsory treatment of all ruminant animals.

H. Q Fever. (Query fever)
This 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 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. In ensuing years, *C. burnetii* was 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 immediately because this rickettsial pathogen had been reported as occurring naturally in humans only in Queensland, Australia. The need to consider Q fever in the differential diagnosis of primary atypical pneumonia was recognized during this period, but it took several years for this knowledge to become widespread in field military medicine. The British Army in the Mediterranean experienced several localized epidemics of atypical pneumonia characterized by a high attack rate, up to 50% in some units. This was probably Q fever, but no serological proof was ever obtained. Three cases of Q fever were recorded in U.S. military personnel during the Persian Gulf War.

Disease Distribution. *Coxiella burnetii* has been reported from at least 51 countries. Incidence is greater than reported because of the mildness of many cases. Infection of livestock with *C. burnetii* was reported from Trinidad in the mid-1990s, and the disease may be focally enzootic at low levels in other parts of the Caribbean. However, no human cases have been reported in recent years.

Transmission Cycle(s). In nature there are 2 cycles of infection with *C. burnetii*. One 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. High seroprevalences of *C. burnetii* antibodies have also been found in wild brown rat populations from 4 Oxfordshire farmsteads in Great Britain. This finding is the first report of *C. burnetii* among domestic rats outside India and suggests that commensal rodents may constitute an important reservoir for this pathogen. These results have not been confirmed in the Caribbean.

The other Q fever cycle is maintained among domestic animals. Although humans are rarely, if ever, infected by ticks, arthropods may transmit the infectious agent 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, it can become aerosolized, causing widespread outbreaks in humans and other animals, often at great distances from the place of origin. Dust in sheep or cattle sheds may become heavily contaminated. Once established, animal-to-animal spread of *C. burnetii* is maintained primarily through airborne transmission. Airborne particles containing rickettsiae can be carried downwind for a mile or more. Outbreaks of Q fever in humans have been traced to consumption of infected dairy products and contact with contaminated wool or hides, infected straw, and infected animal feces. *Coxiella burnetii* may enter the skin through minor abrasions or mucous membranes. Although rare, human-to-human transmission of Q fever has occurred. Presence of the infectious agent in the blood and tissues of patients may pose a hazard to medical and laboratory workers.

Vector Ecology Profiles. Several species of ixodid ticks transmit *C. burnetii* to animals but are not an important source of human infection. Recent isolations of *C. burnetii* from Caribbean ticks have not been reported.

Vector Surveillance and Suppression. Although no commercial vaccine is available in the U.S., effective experimental vaccines have been developed. Severe local reactions occur in individuals with a positive skin or antibody test or a documented history of Q fever. Measures 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 consumption of local dairy products and contact with domestic animals, hides or carcasses. Soldiers should not rest, sleep, or work in or near animal sheds or other areas where livestock have been housed.

I. Relapsing Fever (tick-borne). (Endemic relapsing fever, cave fever)
This is a systemic spirochetal disease characterized by periods of fever alternating with afebrile periods. 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.

Mortality is seldom high, but morbidity may be severe. Illness is effectively treated with antibiotics. A number of species of *Borrelia* are responsible for the disease, but the taxonomy of these pathogens 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 have 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 the low incidence and focal nature of this disease in the Caribbean.

Disease Distribution. Worldwide, several hundred human cases are reported annually. The disease is endemic in east, central, and southern Africa, and throughout the Mediterranean region, extending eastward through Iran, Central Asia, and Kashmir (India) to western China. The status of tick-borne relapsing fever is unclear in the Caribbean. Only sporadic cases have been reported and its current prevalence is unknown. The last reported case occurred during 1987 in a park ranger working in the U.S. Virgin Islands National Park, St. John. Serological tests indicated that the infection was due to a spirochete related or identical to *B. hermsii*, which is a major pathogen in enzootic areas of the western U.S. This was the first report of the disease from the Virgin Islands, although relapsing fever has previously been reported from Puerto Rico and Central America.

Transmission Cycle(s). Soft ticks of the genus *Ornithodoros* (family Argasidae) transmit 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. 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 fluids exuded from pores in the basal leg segments (coxae). 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. *Ornithodoros* spp. ticks are the vectors of tick-borne relapsing fever in most endemic areas of the world. *Ornithodoros rudis* and *O. talaje* are vectors in Central and South America, while *O. hermsi* and *O. turicata* are primary vectors in the U.S. *Ornithodoros coriaceus*, *O. dugesi*, *O. kelleyi*, *O. puertoricensis*, *O. talaje* and *O. turicata* have been collected from the Caribbean and are considered to be potential vectors of African swine virus, which causes a serious veterinary disease of the region. One or more of these species may also be vectors of relapsing fever in the Caribbean. In addition, *O. denmarki* and *O. capensis* have been collected from colonies of marine birds in Cuba, and *O. viguerasi* and *O. tadaridae* have been collected feeding on bats in Cuban caves. The latter species has also been collected from palms where bats roost. *Ornithodoros brodyi* is another cave-dwelling species reported from Dominica. In addition to its role in the transmission of relapsing fever, the genus *Ornithodoros* is important because it includes several species that inflict painful bites, some of which cause local or systemic reactions in humans. Most *Ornithodoros* ticks inhabit 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, piggeries, animal pens and places where host animals rest. Adult *Ornithodoros* spp. feed at night, usually for only 1 to 2 hours. Males are slightly smaller than females but similar in appearance. Larvae may remain attached to their hosts for several days. Subsequent nymphal stages are active and require blood meals in order to develop. Engorgement is rapid, and nymphs drop off their hosts after feeding. Nymphs and adults of most species feed quickly and painlessly, so their bites may go undetected by the human host until well after the ticks have detached. After a variable number of molts (generally 4 to 5), adults emerge and mate. In contrast to ixodid (hard) ticks, female *Ornithodoros* 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 the female, the number of eggs deposited may total several hundred, with up to 8 batches of eggs produced.

Vector Surveillance and Suppression. Argasid ("soft") ticks like *Ornithodoros* are found in the restricted habitats of their hosts and rarely move very far. They occupy loose, dried soil of dwellings, cracks and crevices in mud-walled animal shelters, animal burrows and resting places, and the undersides of tree bark. 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. *Ornithodoros* ticks also fluoresce under ultraviolet light. There is little seasonal fluctuation in numbers of argasids 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 infested with *Ornithodoros* ticks. Troops should avoid using indigenous shelters, caves, old bunkers, or areas frequented by domestic animals for bivouac sites or recreational purposes. Control of small mammals around cantonments can eliminate potential vector hosts. Rodent-proofing structures to prevent 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 Appendix E for **personal protective measures**.

J. Chagas' Disease. (American trypanosomiasis)

This disease is caused by the flagellate protozoan parasite *Trypanosoma cruzi* and occurs in 2 stages. Virulence may vary from one strain to another and between geographic areas. The acute disease appears 5 to 14 days after the bite of the insect vector or 30 to 40 days after infection by blood transfusion. Acute disease is usually seen in children and is characterized by fever, malaise, swelling of the lymph glands, enlargement of the liver and spleen, and inflamation at the site of infection that may last up to 8 weeks. Occasionally there is unilateral swelling of the face or eyelid known as Romaña's sign. Most acute cases resolve over a period of 1 to 3 months even without treatment. Most people have no acute clinical manifestations and may remain without symptoms for many years. Medication is only effective when administered during the acute stage of infection.

A chronic form of the disease may develop 10 to 20 years after the initial infection, causing irreversible damage to the heart, esophagus and colon, with destruction of the peripheral nerves of these organs. About 30% of those infected develop cardiac symptoms that may lead to heart failure, and about 6% develop digestive tract damage characterized by gross organ enlargements known as megaesophagus and megacolon. Not everyone infected by *T. cruzi* develops chronic forms of the disease. There are no effective treatments for chronic Chagas' disease.

Infection with *T. rangeli* occurs in focal areas of endemic Chagas' disease that extend from Central America to Colombia and Venezuela. A prolonged parasitemia occurs, sometimes coexisting with *T. cruzi* (with which *T. rangeli* shares reservoir hosts and vectors), but no clinical symptoms have been noted with *T. rangeli* infection. Detection of *T. rangeli* flagellates in the blood may confuse clinicians diagnosing Chagas' disease. Serological tests are more useful in chronic Chagas' disease.

Diagnosis of Chagas' disease in the acute phase is achieved by microscopic demonstration of *T. cruzi* in the blood, isolation of the parasite by inoculation of infected blood into mice or cell culture, and by xenodiagnosis (feeding noninfected bugs on the patient and finding the parasite in the gut or feces of the bug several weeks later).

Military Impact and Historical Perspective. Chagas' disease is named after the Brazilian physician Carlos Chagas, who first described the parasite in 1909. Chagas' disease poses little threat to military personnel operating in the Caribbean due to its extremely low prevalence in the region. However, in highly endemic areas military personnel may contract the disease but not be diagnosed until chronic symptoms appear long after initial infection. The disease is also a significant threat to the blood supply. Infection by blood transfusion is common in Central and South America, where infections in blood banks in selected cities vary between 3.0 and 53.0%. In some countries blood is not always screened for evidence of *T. cruzi* infection.

Disease Distribution. The geographic distribution of human *T. cruzi* infection extends from Mexico to the south of Argentina. Five infections have been acquired in the U.S. (4 in Texas and 1 in California). Chagas' disease is endemic in 21 countries and affects 16 to 18 million people in Latin America; about 100 million (25% of the population) are at risk of acquiring the disease. Since 1960, *T. cruzi*, blood-sucking triatomine vectors, and wild animals infected with the parasite have been reported from Aruba, Curaçao, Jamaica, and Trinidad and Tobago in the Caribbean. Competent vectors also occur on several other Caribbean islands. The risk of transmission is highest in Trinidad, but some serological surveys in the 1990s indicate that transmission to humans is not occurring or occurs at extremely low levels. However, 38% of blood samples taken from 192 cardiac patients seen at the General Hospital, San Fernando, Trinidad, from May to August of 1992 were seropositive for *T. cruzi*. Forty-nine of the 72 seropositive patients had *T. cruzi* parasites in the peripheral blood. Transmission of Chagas' disease in the Caribbean is probably limited to Trinidad (Figure 6.).

The risk of infection with Chagas' disease is directly related to poverty. The primary vectors inhabit cracks and crevices in houses constructed from mud, adobe or thatch. Chagas' disease was primarily rural until the 1970s and 1980s, when mass migrations to urban areas occurred throughout Latin America. The disease is now common in peripheral urban slums of large cities. Conversely, the enormous sylvatic enzootic potential of Chagas' disease is a serious threat to human development of the Amazon.

FIG. 6. ENDEMIC AREA OF CHAGAS' DISEASE IN THE CARIBBEAN (SHADED AREA).

Transmission cycle(s). Triatomine bugs become infected by feeding on human or animal blood that contains circulating parasites. The parasites multiply and differentiate in the insect gut, yielding infective metacyclic trypanomastigotes. During a subsequent bloodmeal on a second vertebrate host, the trypanomastigotes are released in insect feces near the bite site. The host becomes infected through breaks in the skin, mucous membranes or conjunctivae. Inside the host, the trypanomastigotes invade host cells, where they differentiate into intracellular amastigotes. The amastigotes multiply and change into trypanomastigotes that are released into the circulation as blood stream trypanomastigotes. Replication of trypanomastigotes resumes when they enter another cell or are ingested by a vector. Vectors remain infected for life. *Trypanosoma cruzi* can also be transmitted through blood transfusion or organ transplantation from an infected donor and can cross the placenta to cause congenital infection.

Besides humans, over 150 species of wild and domestic animals may serve as reservoirs of *T. cruzi*, including dogs, cats, rodents, marsupials, edentates, bats, carnivores and primates.

Vector Ecology Profile(s). The family Reduviidae of the order Hemiptera consists of about 20 subfamilies. All are predaceous except the subfamily Triatominae, which has evolved from a predacious to a blood-sucking way of life. Triatomines are commonly known as conenoses or kissing bugs in the U.S. but are called vinchura, pito, chupon, chirmacha, and chinche in Latin America. *Trypanosoma cruzi* is capable of developing in nearly any species of triatomine bug. Of the 90 species known from the Americas, at least 53 have been found naturally infected,
although only about a dozen species live in close association with and transmit the parasite to humans. Vector potential is directly dependent on a bug's tendency to colonize human habitations.

Triatomines are stout-bodied insects with a very long proboscis that is folded back under the head and abdomen, although the head itself is held horizontally. Adults may reach 25 to 30 mm in length. The bite of some species can be painful, especially if it is a defensive bite that is inflicted when handled. However, the feeding bites of most primary vectors are painless and may not be noticed by the host. Serious allergic reactions to bites may occur in some people.
Both male and female bugs imbibe blood, primarily at night. Engorgement can require up to 30 minutes. Each of the 5 nymphal instars must have a bloodmeal before it can molt. However, nymphs can survive for several weeks without feeding if no hosts are available. Most triatomines require 5 to 12 months to complete their life cycle, although a longer period may be required. Triatomine species are hardy and can withstand a broad range of temperatures and humidities. A fertilized female may deposit up to 600 eggs over a 3 to 6 month period and may live for over a year. The eggs are large and pearly and hatch in 10 to 30 days. Dispersal occurs after feeding, although often it is limited to the nearest house or the nearest host nest. Populations of triatomines tend to be small, with fewer than 10 bugs occurring per bird or rodent nest.

Very few vectors that readily feed on humans have been reported from the Caribbean. Most triatomines known in the Caribbean are sylvatic vectors of *T. cruzi* that feed on wild or domestic animals. In Trinidad, *Rhodnius pictipes* occurs in palm trees as well as peridomestic areas but does not inhabit houses. It is considered to be a sylvatic species and does not feed on man. *Panstrongylus geniculatus* is found in caves, burrows and hollow trees in Trinidad and is the main sylvatic vector of *T. cruzi* on that island. It feeds primarily on armadillos. *Panstrongylus rufotuberculatus* is another sylvatic species in Trinidad that may occur in houses but does not establish breeding colonies in them. *Triatoma flavida* occurs in bat caves in Cuba but usually feeds on small mice of the genus *Capromys*. Although it may occur in houses, it primarily inhabits the burrows of *Capromys* spp. It is widespread and the most abundant of the potential vectors in Cuba, but it is more likely to be found in rural than urban areas. *Triatoma flavida* is attracted to light and may enter houses to bite humans. *Triatoma maculata* occurs in Aruba, Bonaire, and Curaçao, where it is often found in and around human habitations. These triatomines are common in palm trees. *Triatoma maculata* seems to prefer birds, including chickens; consequently, large numbers may be found in poultry houses. It will also feed on dogs, cats, rodents and pigs. It is sometimes attracted to lights but seldom bites humans. *Triatoma rubrofasciata* is the most widely distributed of the triatomines in the Caribbean and occurs in Antigua, the Bahamas, Cuba, the Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, St. Croix, St. Vincent, Trinidad, and the Virgin Islands. It often occurs in urban areas. This is a domestic species that commonly feeds on roof rats and man. *Triatoma obscura* is known only from the interior highlands of Jamaica, where it probably feeds on one or more species of bats that live in caves or hollow hardwood trees.

Vector Surveillance and Suppression. Military personnel should not utilize native adobe structures or habitations with thatched roofs. Cracks and crevices of buildings can be inspected for bugs with a flashlight and treated with an approved residual insecticide if infested. Pyrethroids have been the insecticides of choice in most public health programs. Pyrethrin and some pyrethroids may also be used to flush kissing bugs from hiding places. Animal burrows, tree cavities, palm trees and rocky crevices are habitations to survey near military bivouac sites. Wild animal harborages should be destroyed within 100 m of bivouac areas. Military structures should be constructed to exclude reservoirs of Chagas' disease. Use bed nets in infested areas. The repellents recommended in the **DoD arthropod repellent system** are effective against kissing bugs.

K. Other Arthropod-borne Viruses.

Many enzootic arboviruses are circulating in the Caribbean, but little is known about them. Available epidemiological information indicates that they would have a minor impact on military operations. However, medical personnel should be aware of these arboviruses because they will frequently be treating fevers of unknown origin and, in serological tests, may see reactions to closely related viruses known to cause disease in the region. In 1953 the Trinidad Regional Virus Laboratory was established by the Rockefeller Foundation in Port of Spain. During the next 15 years, many arboviruses circulating in the Caribbean were discovered, and their basic epidemiology was outlined. Though numerous arboviruses have been isolated in Trinidad, little is known about their ecology in other parts of the Caribbean and their role in human disease. The following arboviruses are the most medically significant to military personnel.

Oropouche virus (*Bunyavirus*, Bunyaviridae) was first isolated from the blood of a febrile forest worker in Trinidad in 1953. Sporadic isolations have been made from *Aedes* and *Coquillettidia* mosquitoes in Trinidad, but epidemics of Oropouche fever have occurred primarily in Brazil, Colombia and Peru. The primary epidemic vector is *Culicoides paraensis*. Numerous isolations have been made from *Culex pipiens* *quinquefasciatus* in Brazil, but humans generally do not circulate enough virus in the bloodstream to infect this mosquito, and numerous laboratory studies have incriminated *C. paraensis* as the primary vector. The zoonotic cycle of the virus is poorly understood. Primates, sloths and possibly birds appear to be the vertebrate reservoirs and an as yet unknown arthropod(s) serves as the zoonotic vector(s). *Culicoides paraensis* is present in Trinidad and Tobago, and its biology is similar to that of *C. furens*, discussed under mansonellosis. Oropouche fever in humans is characterized by abrupt onset, fever, headache, muscle and joint pain, and photophobia. Nausea, vomiting, and diarrhea may also occur. Clinical illness persists for 2 to 7 days; recovery is followed by long-lasting immunity against reinfection. At least 130,000 cases occurred during the 1978 to 1980 epidemic that swept through Para State in Brazil. Human cases of oropouche fever have not been reported from Trinidad for many years, so the disease currently poses little threat to military personnel operating in the Caribbean.

Mayaro virus was first isolated in 1954 from the blood of 5 febrile patients in Trinidad. It is an *Alphavirus* in the family Togaviridae and is closely related to Semliki Forest virus in Africa. Human epidemics of Mayaro virus have occurred in rural areas of South America, primarily Bolivia and Brazil. Humans are the only known host to develop significant disease following Mayaro virus infection. Clinical cases are characterized by fever, headache, nausea, vomiting, diarrhea, generalized joint and muscle pain, and sometimes a rash of 3 to 5 days duration. Joint pain can persist for months and can be incapacitating. There is little risk of mortality. In the Caribbean, risk of infection appears to be confined to the forests of Trinidad. Nonhuman primates and *Haemagogus* mosquitoes appear to play important roles in the natural transmission of Mayaro virus, although birds and other mosquitoes have also been implicated in its ecology. Mayaro virus has been isolated from *Mansonia venezuelensis* in Trinidad.

During 1938, Western equine encephalitis (WEE) was isolated in California from brain tissue in a fatal case of human encephalitis. Subsequent research has shown that WEE virus is a complex of several closely related viruses in the genus *Alphavirus*, family Togaviridae. Most human infections are inapparent, and clinical infections range from fever and headache to severe encephalitis. WEE is clinically indistinguishable from St. Louis encephalitis. Complete recovery is the rule, but mild to severe neurological sequelae may occur, primarily in infants. Case fatality rates are usually <5%. As of June 2001, 639 cases of WEE had been reported since 1964 in the U.S. WEE virus is enzootic in parts of South America, but few human cases have been reported. Serological evidence suggests that WEE virus may be circulating in the Caribbean, and an epizootic occurred on Haiti in the mid 1970s, but no human cases were reported. The ecology of WEE virus in South America and the Caribbean is poorly understood. Nearly all wild birds and mammals are susceptible to infection, as well as some reptiles and amphibians. The virus produces severe morbidity and mortality in equines. Most studies have implicated domestic and wild birds as the primary amplifying hosts. *Culex tarsalis* is the primary vector in North America, although WEE virus has been isolated from a wide variety of mosquitoes, including species in the genera *Aedes*, *Culiseta* and *Psorophora*. Several species of *Culex* are competent vectors, including *Cx. quinquefasciatus*. Methods for the surveillance and control of WEE are the same as for other mosquito-borne encephalitides. A commercial vaccine is available for horses but not for humans.

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. Incubation in humans may take as little as 10 days or more than 6 months. Symptoms include ulcerative cutaneous lesions (cutaneous leishmaniasis or CL), multiple dry lesions leaving scars (diffuse cutaneous leishmaniasis, or DCL), lesions in the mucosal areas of the mouth and/or nose (mucocutaneous leishmaniasis or MCL), and 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). VL is a serious disease that is difficult to treat and can cause high mortality rates.

Diffuse cutaneous leishmaniasis in the Caribbean and the Americas is caused by *Le. mexicana* and typically appears as multiple dry raised papules that may develop into non-healing ulcers. The lesion(s) usually develops within weeks after a sand fly bites. Lesions normally heal quickly and provide lifetime immunity against that species of *Leishmania*. Scars associated with the healing of lesions are often evident in rural populations in endemic areas of Central and South America. Cases of CL have been reported from Trinidad. *Leishmania amazonensis* or a closely related species is probably responsible for these cases.

Visceral leishmaniasis (Kala-azar, Dum Dum fever), caused by *Le. chagasi* in Central and South America, is a severe form of leishmaniasis, with as much as 95% mortality in untreated cases. It is a chronic disease characterized by fever (2 daily peaks), weakness and, as the parasites invade internal organs, weight loss coupled with enlargement of the spleen and liver that may resemble severe malnutrition. It should be noted that cutaneous lesions may also be seen in human visceral leishmaniasis cases, but the chronic visceralizing nature of the disease is the main medical concern.

Military Impact and Historical Perspective. Diagnosis of leishmaniasis is difficult, and providing proper care for service members who may have been infected is a long, costly and complex process. Treatment usually requires 20 or more 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 U.S. $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. Since both CL and VL are of limited known prevalence in the Caribbean, they should have little or no impact on military personnel operating in the region. Medical personnel should be aware of the epidemiological history of leishmaniasis in the region and the potential for leishmaniasis to cause post-deployment diagnostic problems and threaten blood supplies. Returnees from the Persian Gulf War were barred from donating blood for up to 2 years, severely impacting blood supplies.

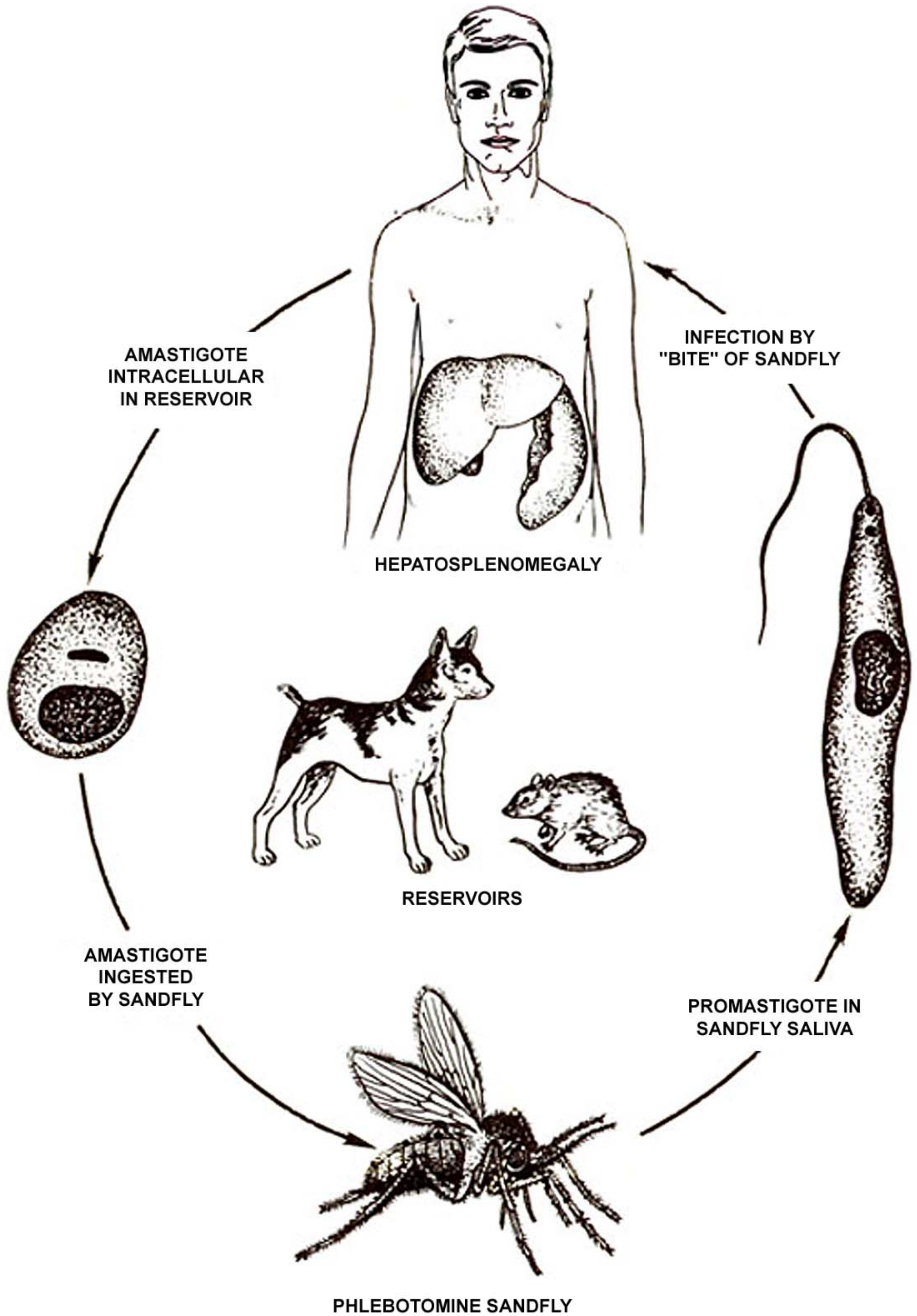
Disease Distribution. There is little risk of leishmaniasis transmission on the majority of the Caribbean Islands (Figure 7). However, CL occurs in the Dominican Republic and may be present in Haiti, Martinique, Trinidad and Guadeloupe. The first cases of CL in the Dominican Republic were described in 1975 during a survey for leprosy. By 1984, 24 cases had been described. Subsequent immunological surveys indicated that CL infections are commonly subclinical and may be more widespread in the Dominican Republic than suspected. The disease may be unrecognized because of other skin problems that are more prevalent. Although no cases of CL have been reported in Haiti, its geographic proximity to the Dominican Republic and shared fauna suggest that CL may be present. Three indigenous cases of CL were reported decades ago in Martinique, but none have been reported recently. A case of VL caused by an unknown parasite was found nearly 40 years ago in a young girl on Guadeloupe; this is the only reported case of VL acquired in the Caribbean. Although VL on Guadeloupe has never been confirmed, the possibility that it occurs there should not be discounted. A case of CL in an AIDS patient was reported from Guadeloupe in the 1990s. Cases of CL were reported before 1930 in Trinidad, but there have been none since. Imported cases of leishmaniasis are frequently reported in some Caribbean counties due to the number of Caribbean nationals that work in other parts of Central and South America, where both CL and VL are endemic.

Transmission Cycles. In rural areas, hosts of *Le. amazonensis* may include wild or feral rodents living in close proximity to humans. Sand fly vectors inhabit the burrow systems of domestic and wild rodents, moles and marsupials and acquire infections while feeding on these reservoir hosts. On Trinidad, CL is found in small mammals (*Oryzomys capito*, *Proechymis guyanensis* and *Heteromys anomalus*) and marsupials (*Marmosa mitis*, *M. fusca* and *Caluromys philander*). The black rat, *Rattus rattus*, is the only known reservoir of CL in the Dominican Republic. Amastigotes (the mammalian form of the *Leishmania* parasite) 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 help maintain *Leishmania* infections in the flies. 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 able to lay its eggs, infective metacyclic promastigotes are ready to be transmitted to the next vertebrate host when the sand fly feeds again (Figure 8).

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. This inflamed area is where 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 *Le. amazonensis*, eventually heal to form the characteristic scars seen on large numbers of people in some endemic areas.

FIG. 7. ENDEMIC AREAS OF CUTANEOUS LEISHMANIASIS IN THE CARIBBEAN (SHADED AREAS).

FIGURE 8. LIFE CYCLE OF *LEISHMANIA*



Vector Ecology Profiles. All vectors of leishmaniasis in the New World belong to the sand fly genus *Lutzomyia*. The general biology of sand flies in this genus is similar to that of sand flies belonging to the genera *Phlebotomus* and *Sergentomyia*.

The incriminated sand fly vector of *Le. mexicana* (DCL) in the Dominican Republic is *Lu. christophei*. It has been suggested that the sand fly *Lu. atroclavata* (previously identified as *L. guadeloupensis*) was a possible vector of *Le. chagasi* on the island of Guadeloupe, since it was the only sand fly collected in past surveys. However, since this species is not anthropophilic, there is no evidence to support this hypothesis. In Martinique, *L. atroclavata* has been suggested as the vector of CL. Trinidad has a number of potential sand fly vectors, many of which also occur on the mainland of South America. Several of these sand flies (*Lu. antunesi*, *Lu. gomezi, Lu. migonei*, *Lu. ovallesi,* and *Lu. shannoni*) readily attack humans. In Trinidad, CL is maintained in an enzootic cycle by the sand fly *Lu. flaviscutellata* among wild rodents. *Lutzomyia gomezi* is found in Trinidad and is the suspected vector of *Le. panamensis* in Panama. *Lutzomyia shannoni* is also found in Trinidad and is highly anthropophilic and a suspected leishmania vector. *Lutzomyia flaviscutellata* is found in Trinidad and is a proven vector of *Le. amazonensis* in Brazil and French Guiana. *Lutzomyia antunesi* has been found naturally infected with *Leishmania* flagellates in Brazil.

Adult sand flies rest during the day in dark, humid, protected areas, such as rodent burrows, rock crevices and caves. The preparation of military bunkered ground positions in sandy areas provides additional protected daytime resting sites for phlebotomine 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, secluded areas. The adult female has been observed to spread eggs around rather than oviposit in a single site. In military fortifications, eggs may be deposited in the cracks between stacked sandbags. Eggs hatch in 1 to 2 weeks, and the minute caterpillar-like larvae feed on mold spores and organic debris. The larvae go through 4 instars and then pupate near the larval habitat. There is no cocoon; rather, the pupa is loosely attached to the substrate by the cast skin of the fourth larval instar. Development from egg to adult requires 30 to 45 days, depending on feeding conditions and environmental temperatures. Fourth-instar larvae may diapause for weeks or months if environmental conditions are excessively cold or dry. Phlebotomine sand fly eggs, larvae and pupae have seldom been found in nature, although exhaustive studies and searches have been made. The larvae are widely distributed in the environment but are probably below the ground surface in termite mounds, rodent burrows, caves, or cracks and crevices in the soil where temperature, humidity and mold growth provide ideal conditions for larval development.

Adult movement is characterized by short, hopping flights just above the ground surface to avoid wind. Adult sand flies are weak fliers and generally do not travel great distances. Most flights are believed to be less than 100 m, although unengorged females occasionally disperse as far as 1.5 km. Sand fly habitats in the region range in altitude from desert areas below sea level to 3,500 m in the mountains. Adult sand flies are most abundant and active during warm humid periods, especially after rains.

Female sand flies are quiet "stealth biters," and their bites may go unnoticed by military personnel. On humans, sand flies feed on exposed skin around the head, neck, legs, and arms. Female sand flies will crawl under the edges of clothing to bite skin where repellent was not applied. Persons newly exposed to the bites of sand flies often experience a severe urticarial reaction until they become desensitized. Sand flies feed outdoors or indoors and readily penetrate ordinary household screening. Sand fly activity is nocturnal, although they may also bite during the day if disturbed in their secluded, shaded resting sites. Areas with some vegetation and cliffs, rock outcroppings, or other geologic formations that provide 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 the Caribbean remain unsurveyed for sand fly vectors and disease. When searches are made, sand fly vectors are often found in areas where they were previously unknown.

Vector Surveillance and Suppression. Because sand flies are small and retiring, specialized methods are required to collect them. The simplest method is active searching of daytime resting sites with an aspirator and flashlight, but this method is very labor intensive. Human-landing collections are an important method of determining 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 and crevices, in building debris, and in local vegetation where sand flies are likely to rest during daytime hours. A variety of light traps have been used to collect phlebotomines, but their effectiveness varies according to the species being studied and the habitat. Light traps are inefficient in large open areas. Light traps used for mosquito collection should be modified with fine mesh netting in order to collect sand flies. Traps using animals as bait have also been devised. Collection of larvae is extremely labor intensive and usually unsuccessful because specific breeding sites are unknown or hard to find and because females deposit eggs singly over a wide area. Emergence traps are useful for locating breeding sites. Identification of sand flies requires a microscope and some training; however, with a little experience, sorting and identification by color and size will suffice using minimal magnification if only a few species are involved. For accurate species identification, laboratory microscopes with 100x magnification are required.

Because of their flight and resting behavior, 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 distance of 100 m around encampment sites may be helpful. Some success in reducing vector populations has been achieved by controlling the rodent reservoir or host population. Selection of encampment sites without vegetation or rock outcroppings that harbor rodents is important. Cleanup and removal of garbage and debris that encourage rodent infestation are necessary for longer periods of occupation. Pets must be strictly prohibited, because any small rodent and/or local dog may be infected with leishmaniasis or other diseases.

Sand flies are able to penetrate standard mesh screening used on houses and standard mesh bednets (seven threads per cm or 49 threads per sq cm). These items should be treated with permethrin to prevent entry. Fine mesh (14 threads per cm or 196 threads per sq cm) bednets can be used to exclude sand flies, but these are uncomfortable under 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 BDU to prevent sand flies from crawling under the fabric and biting. The use of **personal protective measures** (see TG 36) is the best means of preventing sand fly-borne disease.

B. Schistosomiasis. (Bilharziasis, Snail fever)
This disease is caused by trematodes in the genus *Schistosoma* 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. The World Health Organization considers 5 species of schistosomes significant in terms of 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 manifestations. The most severe pathological effects are the complications that result from chronic infection. Depending on the parasite species, symptoms of acute disease appear 2 to 8 weeks after initial infection and can be intense, especially in nonimmune hosts. Clinical manifestations 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 among 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 engaged in Mesopotamia and various 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, Chinese troops training along the Yangtze River for an amphibious landing on Taiwan contracted 30,000 to 50,000 cases of acute schistosomiasis. As a result, 10 to 15% of the invasion force became ill, and the invasion had to be canceled. 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 due to *S. mekongi* was rare among U.S. military personnel during the Vietnam War.

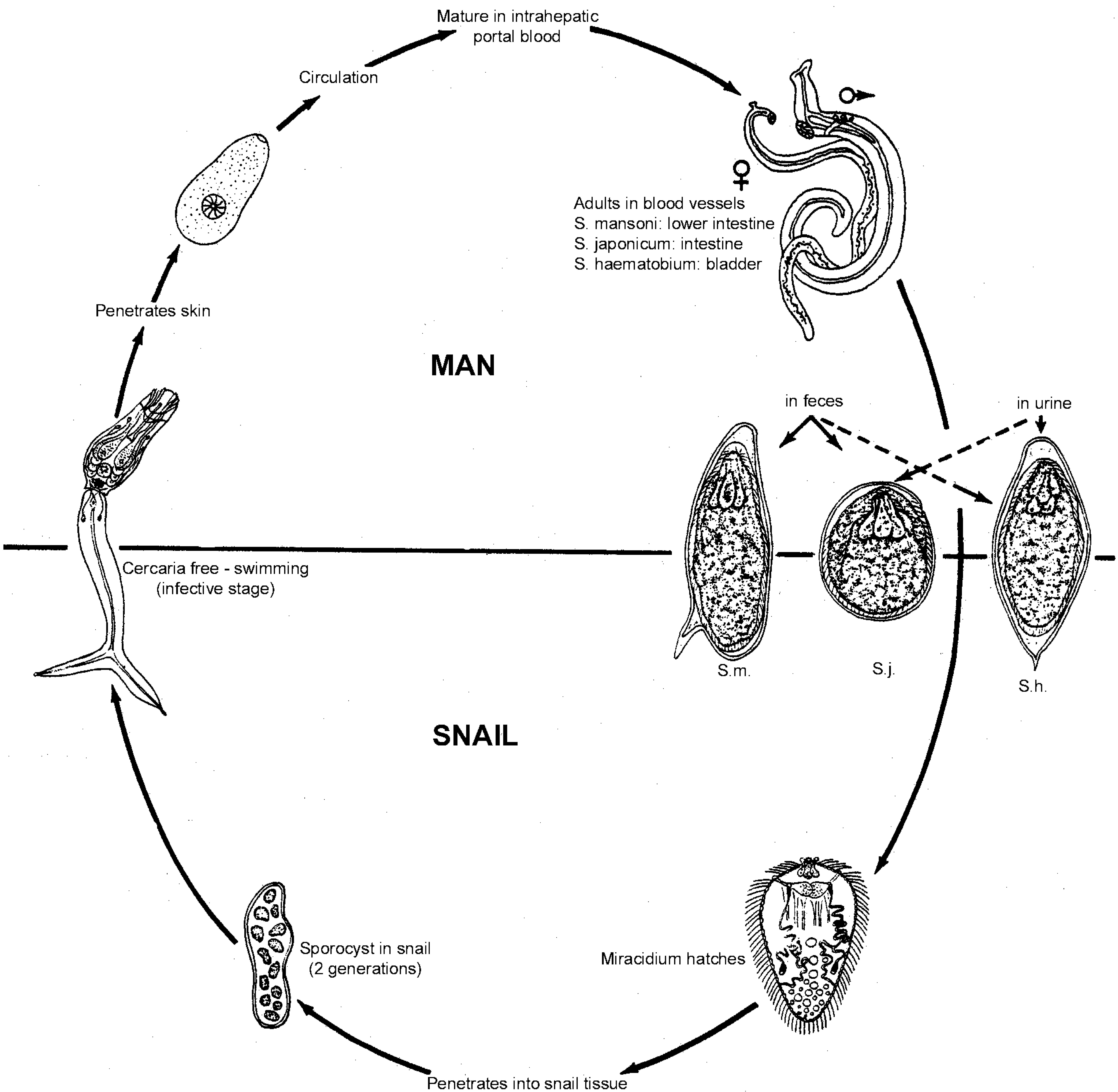
Disease Distribution. Over 200 million persons are infected with schistosomiasis worldwide, causing serious acute and chronic morbidity. The risk of infection with *S. mansoni* in the Caribbean is currently confined to fresh water in parts of the Dominican Republic, Guadeloupe, Martinique, Montserrat, Puerto Rico, and St. Lucia (Figure 9). Prevalence of schistosomiasis on Montserrat is low, and the disease is under control on St. Lucia. Only a few cases of schistosomiasis are annually diagnosed on Martinique. Recent serological surveys indicate that the prevalence of schistosomiasis on Puerto Rico greatly diminished during the 1990s. The seropositive rate in a study population from the Caguas region decreased from 21% in 1993 to 1% in 1998. Seroprevalence data for the past 20 years indicate that schistosomiasis has been transmitted on Puerto Rico in a focal manner. Imported cases of *S. haematobium* have been reported from Cubans returning home after working in Angola.

Transmission Cycle(s). The life cycles of the various schistosomes infecting man are similar. A generalized life cycle appears in Figure 10. 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 to 24 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, but infectivity declines rapidly within 4 to 6 hours. 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.

Transmission of *S. haematobium* is essentially a man-snail-man cycle, with reservoir hosts playing an insignificant role in the maintenance of the disease. *Schistosoma mansoni* is mainly a man-snail-man cycle in Africa and Southwest Asia. In the West Indies, other mammals, particularly rodents,

FIG. 9. ENDEMIC AREAS OF SCHISTOSOMIASIS IN THE CARIBBEAN (SHADED AREAS).

Figure 10. Life Cycle of Schistosomes



can contribute to transmission. The black or roof rat, *Rattus rattus*, is the most common reservoir of *S. mansoni* in the Caribbean. The Norway rat, *Rattus norvegicus*, is commonly infected with *S. mansoni*, but neither adult worms nor eggs are found in the intestinal wall and stools of the Norway rat. Consequently, the Norway rat is a dead-end host for *S. mansoni*. *Schistosoma japonicum* is a true zoonosis. Numerous hosts have been found infected with this parasite, including many species of wild and domestic animals.

Vector Ecology Profiles.

General Bionomics. Vector snails are focally distributed in rural and urban areas, associated with slow-moving streams, irrigation canals, cisterns, and aqueducts. Snails generally increase in number as temperatures rise during warm weather. Population density is heavily dependent on rainfall, and snail habitat may temporarily increase after flooding. Expansion of the number of irrigation projects on some Caribbean islands has increased the habitats for snails. Concrete-lined, covered canals are usually poor habitats, while soil-lined canals that allow reeds or other marshy vegetation to grow provide excellent snail habitats. Tidal areas are not suitable habitats for snail hosts. Snails survive dry seasons by burrowing beneath river or canal beds or under moist stones. Snails may be transported by man and sometimes by birds. Self-fertilization is common among these hermaphroditic snail species, a characteristic that enhances their dispersal, since only a single founder is necessary to establish a colony. The movement of military equipment from a snail-infested area can export snails of significant medical and economic importance to other regions (Consult TG 31, Contingency Retrograde Washdowns: Cleaning and Inspection Procedures, for the proper procedures to de-snail military equipment).

Specific Bionomics. *Biomphalaria glabrata* is the intermediate host for *S. mansoni* in the Caribbean. This snail is widely distributed in the region, although it has been displaced in many areas through introduction of competitive species. *Biomphalaria glabrata* was common in the French West Indian islands of Guadeloupe, Martinique, and St. Lucia, but it has largely been replaced by the competitor snail *Melanoides tuberculata*. *Biomphalaria glabrata* also occurs widely in the Dominican Republic and to a lesser extent in Haiti. It has been eliminated from the central and northern parts of the Dominican Republic by two competitive species, *Marisa cornuarietis* and *Tarebia granifera*, and *S. mansoni* is not transmitted in Haiti. Three other species of *Biomphalaria* (*B. straminea*, *B. havanensis* and *B. helophila*) also occur in the Dominican Republic but are poor hosts of *S. mansoni*. By the mid-1990s, competition from *M. cornuarietis* and *T. granifera* had nearly eliminated *B. glabrata* from Puerto Rico. *Biomphalaria havanensis* occurs in Cuba, but it is not a host of *S. mansoni*.

Historically, *B. glabrata* has also occurred on Vieques, St. Maarten, St. Kitts, Montserrat, and Antigua. *Biomphalaria glabrata* reportedly was eliminated from St. Kitts and Vieques by 1980. This snail has never been reported from Trinidad, Grenada, St. Vincent or Barbados.

Biomphalaria glabrata is abundant during the rainy season in temporary standing water sources, such as irrigation channels, drainage ditches, concrete-lined tanks, mangrove forest ponds, artificial lakes, swamps and streams. It usually occurs together with water lettuce, *Pistia stratiotes*. This plant is an important food source for *B. glabrata*. The snail is an excellent intermediate host for *S. mansoni,* in part because it thrives in water polluted with human excreta. *Biomphalaria glabrata* develops rapidly at temperatures between 25 and 30°C. Egg laying begins in about 8 to 9 weeks at these temperatures. Sexually mature snails deposit up to 300 eggs every two weeks at 25°C and up to 400 eggs per two weeks at 30°C. Although snails can survive temperatures of 35°C or higher, eggs do not hatch and survival is reduced. If snails are stranded by widely fluctuating water levels, they can survive but they do not lay eggs. Sewer canals where human excreta are discharged play a key role in infecting snails with schistosome miracidia.

Vector Surveillance and Suppression. The most important preventive measure in reducing the incidence of schistosomiasis is avoidance of fresh water with infective cercariae. Military personnel should 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 cercariae can be transported considerable distances by water currents. Combat commanders and troops must be instructed in the risk of infection and measures for schistosomiasis prevention. No topical repellent is currently available that provides long-term protection against cercarial penetration. Experimental studies have shown the insect repellent DEET 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. When DEET is experimentally incorporated into liposomes (LIPODEET), its activity is prolonged for more than 48 hrs after a single application. Commercial formulations that can be used to protect against cercarial penetration may be available in the near future. 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 BDUs 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 and during the evening in the Caribbean, where the peak in *S. mansoni* cercarial activity mirrors the activity of nocturnal rodents that are the primary hosts of this disease. Stepping on and crushing an infected snail will release thousands of cercariae.

Cercariae are killed by exposure for 30 minutes to concentrations of chlorine of 1 ppm. Treating water with iodine tablets is also effective. Heating water to 50°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 also effective in removing cercariae.

Molluscicides can be applied to extensive or limited areas by preventive medicine teams to eliminate snails from aquatic sites that are 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 molluscicide recommendations and application techniques. There is little evidence that snail intermediate hosts have developed resistance to commonly used molluscicides like niclosamide.

Biological control has been used successfully against the intermediate host of *S. mansoni* in the Caribbean. *Bibeiroia guadeloupensis* is a parasitic trematode that sterilizes *B. glabrata* and was used with success in freshwater ponds of Guadeloupe. Greater success has been achieved with several species of competitor snails belonging to the families Ampullariidae (*Pomacea glauca*, *M. cornuarietis*) and Thiaridae (*T. granifera*, *M. tuberculata*). *Biomphalaria glabrata* has been completely eliminated on some islands by competitive displacement. Competitor snails have also proven useful in preventing recolonization by *B. glabrata* after its elimination with molluscicides. Competitor snails are more likely to be successful in permanent bodies of water that are shallow, have emergent plants, and are well oxygenated. On the other hand, competitor snails are at a disadvantage in temporary bodies of water that are extremely deep, poorly oxygenated, or are covered with a dense mat of floating aquatic vegetation.

C. Filariasis.

Bancroftian filariasis is caused by the nematode *Wuchereria bancrofti*, which normally resides in the lymphatic system 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 inflammation of the lymph glands. 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 people are clinically asymptomatic, although they have microfilariae circulating in their blood and 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 manifestations are similar to those of Bancroftian filariasis, except that the recurrent acute attacks of filarial fever and inflammation of the lymph glands 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 in the blood of a patient in Brazil in 1878. 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 costs 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. Mass migrations of infected humans are usually required in order to introduce the disease to new areas. The nocturnally periodic form of *Brugia 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.

It is estimated that 1 billion people are at risk of acquiring infection. Over 120 million people in at least 80 countries are currently infected with some form of filariasis, and 40 million of these are seriously incapacitated and disfigured by the disease. At least one-third of the people infected with the disease live in India. Ninety percent of infections worldwide are caused by *W. bancrofti*, and most of the remainder by *B. malayi*.

> Bancroftian filariasis was brought to the Caribbean by African slaves. The disease has historically been endemic in the Lesser Antilles from Trinidad north to Guadeloupe. Recent studies suggest that Bancroftian filariasis may no longer be present in Trinidad, and its status in other islands of the Lesser Antilles is unclear. The highest risk exists in Haiti, and the Dominican Republic (Figure 11). *Wuchereria bancrofti* was first described in Haiti in 1786 and continues to be a public health problem in urban and suburban areas of the humid northern coastal plain around the Gulf of Gonava. During the late 1990s, microfilariae were found in 13.3% of Haitian school children. In Leogane, Haiti, *W. bancrofti* antigen prevalence exceeds 50% in adults. Little has been published about filariasis in the Dominican Republic. Known foci include the sugar cane growing areas of the populous south and the southern port cities of Barahona, San Cristobal, Santo Domingo, and San Pedro de Macoris, as well as

FIG. 11. ENDEMIC AREAS OF BANCROFTIAN FILARIASIS IN THE CARIBBEAN (SHADED AREAS).

the eastern tip of the country. Filariasis may still be focally present in western Cuba and parts of Puerto Rico.

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 parasites enter the bloodstream directly during a mosquito bite. A few nematode larvae are deposited on the skin and can enter the host through skin abrasions. In humans, larvae undergo development to adults that produce microfilariae for many years. Over most of the geographic range of this disease, *W. bancrofti* microfilariae exhibit pronounced nocturnal periodicity and consequently are ingested by night-biting mosquitoes. Peak abundance of microfilariae in the blood occurs between 2300 and 0300 hours. *Culex pipiens 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 Bancroftian filariasis.

There are no significant animal reservoirs for nocturnally periodic forms of *B. malayi* or *B. timori*. The subperiodic form of *B. malayi* infects humans and monkeys, especially leaf monkeys *(Presbytis* spp.), wild and domestic cats, and pangolins (scaly anteaters). The zoonotic and epidemic life cycles of subperiodic *B. malayi* usually do not overlap.

Vector Ecology Profiles. *Culex quinquefasciatus* is the primary, if not exclusive, vector of *Wuchereria bancrofti* in the Caribbean because it is highly anthropophilic, and its peak feeding activity, from 2100 to 0300 hours, coincides with the nocturnal periodicity of microfilariae in human blood. *Culex quinquefasciatus* is widespread and abundant throughout the Caribbean because of urbanization, poor sanitation and inadequate disposal of wastewater. In addition to being the primary vector of *W. bancrofti*, it is a major pest mosquito. Over 200 bites per person per night have been observed in some parts of Martinique. Adults usually prefer to feed on birds but readily feed on humans and large animals like cattle and goats. They begin feeding early in the evening, usually within 2 hours of sunset, and feed throughout the night. Adults are strong fliers and will travel 3 to 5 km from breeding sites to find a bloodmeal. *Culex quinquefasciatus* feeds and rests indoors or outdoors. This species is an annoying biter and produces a high-pitched buzzing sound that can easily be heard. Before and after feeding indoors, females rest behind or under furniture and draperies, or in closets. Adults are more endophilic in cool weather. Three or 4 days after a bloodmeal, *Cx. quinquefasciatus* deposits egg rafts containing 75 to 200 eggs on the 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. Polluted water from septic systems is ideal for larvae of this species. Slums with poor sanitation have proliferated in many areas, especially in Haiti and the Dominican Republic, and provide abundant breeding sites for *Cx. quinquefasciatus*. Larval development requires 7 to 9 days at a temperature range of 25 to 30 C. At lower temperatures, larval stages may require 15 to 20 days. The pupal stage lasts about 2 days. *Culex quinquefasciatus* breeds year-round in most areas of the Caribbean. Another mosquito that may transmit filariasis in the Caribbean is *Anopheles* *aquasalis*, which is a known vector in South America and occurs in some endemic areas of filariasis in the Caribbean.

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 to light traps increases the number of species collected, especially *Anopheles*. Traps using animals, or even humans, as bait are useful for determining feeding preferences of mosquitoes. Adults are often 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 not to 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 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, to control filariasis, it is necessary to keep vector density at low levels for prolonged periods. Hence chemotherapy of infected persons to eliminate microfilariae from the blood has been the chief tool to control the disease in endemic areas. Studies in endemic areas in Asia have demonstrated that the incidence of filariasis declines and may disappear within 3 to 5 years when the number of infected humans circulating microfilariae falls below 1% of the population. 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, some populations of *Cx. quinquefasciatus* are now resistant to insecticides (Appendix B. Pesticide Resistance in the Caribbean). Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be used to the extent possible. Placing nontoxic 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. Proper disposal of sewage and waste water is critical to the control of this species, particularly in impoverished areas of the Caribbean.

The proper use of repellents and other **personal protective measures** is thoroughly discussed 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.

D. Mansonellosis.

Mansonellosis is infection by a filarial worm of the genus *Mansonella*. Infection with *M. ozzardi* or *M. perstans* is largely nonpathogenic. Adult worms produce little tissue reaction. The latter species may produce a mild pathology in persons from nonendemic areas that includes subcutaneous swelling, transient abdominal pain, and fatigue. Infection with *M. ozzardi* has been asymptomatic in people living in endemic areas who have up to 30,000 microfilariae per ml of blood and up to 20,000 microfilariae per gm of skin. Infection with *M. streptocerca* causes hypopigmented macules, itching and swollen lymph glands. Infections are easily treated with ivermectin.

Historical Perspective and Military Importance. *Mansonella ozzardi* was described by Manson in 1897 as *Filaria ozzardi*. In 1929, when the genus *Mansonella* was erected, *M. ozzardi* was designated as the type and only species. *Mansonella perstans* was first observed by Daniels in 1898 and *M. streptocerca* was first described in 1922. Both species were initially assigned to different genera but were transferred to *Mansonella* in 1976. The presence of *M. ozzardi* in Haiti was recognized by Rockefeller scientists, who conducted an investigation of its distribution between 1915 and 1934. Few studies were conducted on mansonellosis between 1935 and 1971, and our current knowledge of this parasite and its vectors is based on investigations since 1972.

Mansonellosis is of little military importance due to the benign nature of the infection. Medical personnel should be aware of its presence in the Caribbean in order to distinguish it from *Wuchereria bancrofti* and other filarial nematodes that may infect humans.

Disease Distribution. *Mansonella streptocerca* occurs only in West Africa. *Mansonella perstans* is widely distributed throughout tropical areas of Africa, coastal South America and Central America. This species is probably confined to Trinidad and Tobago in the Caribbean. *Mansonella ozzardi* is a New World filaria that is widely distributed in Central and South America. It is present in the Caribbean, notably in Haiti and the Dominican Republic, and in some islands of the Lesser Antilles (Figure 12).

Transmission Cycle(s). Adult worms of *M. ozzardi* and *M. perstans* reside primarily in the peritoneal and pleural cavities, rarely in the pericardium. Adult *M. streptocerca* live in the skin, usually less than 1mm below the surface. Humans are the most important definitive host, although primates are significant reservoirs in some areas. Microfilariae circulate in the peripheral blood and undergo a cycle of development after ingestion by appropriate blood-sucking insects, usually *Culicoides* midges or black flies of the genus *Simulium*. Microfilariae generally do not exhibit pronounced periodicity in the bloodstream.

FIG. 12. ENDEMIC AREAS OF MANSONELLOSIS IN THE CARIBBEAN (SHADED AREAS).

Vector Ecology Profiles. In the Caribbean, *Mansonella ozzardi* and *M. perstans* are transmitted by ceratopogonid midges in the genus *Culicoides*. The general biology of the family Ceratopogonidae is discussed in section VIII. A. 3, Noxious/Venomous Animals and Plants of Military Significance.

Female *Culicoides furens* deposit eggs in batches of 100 or more in coastal mangrove swamps, rice fields and tidal rivers. Eggs cannot withstand desiccation and must remain damp to be viable, with the result that this species is most abundant during the rainy season. Larvae favor mud about one inch above the tidal water line. This enables larvae to pupate and adults to emerge without interference from flooding. Adult midges are extremely pestiferous and frequently attack in large numbers. *Culicoides furens* is a relatively weak flier, seldom traveling more than a few hundred meters from larval breeding habitats. It rarely flies when wind speeds exceed 8 km per hour. Biting activity begins shortly before sunset, continues through the night, and ceases within an hour after sunrise. This species often enters houses to feed, although it usually feeds outdoors. Eggs are laid about 48 hours after a bloodmeal, though autogeny has also been observed. *Culicoides furens* normally transmits infective *Mansonella* larvae only after the third bloodmeal. Midges require 3 to 4 minutes to engorge, and their irritating bites can lead to incomplete feeding unless the host is sleeping.

Culicoides phlebotomus inhabits wet sandy beaches of many Caribbean islands. It is a much larger and stronger flier than *C. furens* and readily travels longer distances from breeding sites to attack humans in coastal villages. Eggs mature 3 days after a bloodmeal. Ingested *Mansonella* microflariae require at least 9 days to develop into infective larvae. *Culicoides phlebotomus* feeds during the day, at dusk, and up to an hour after dawn. It also feeds readily on moonlit nights. It is highly anthropophilic, usually feeding on the legs and ankles, and it readily bites other mammals, including dogs. Like *C. furens*, this species is more abundant in the rainy season.

Culicoides barbosai has been shown to be a competent vector of *M. ozzardi*, and may be a secondary vector in some parts of the Caribbean.

Vector Surveillance and Suppression. Larvae are difficult to find, but adults are easily collected while biting or in light traps equipped with fine mesh nets. Environmental management best controls larval stages, 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 application of aerosols may produce temporary control, but sprayed areas are soon invaded by midges from unsprayed areas. Ceratopogonids have difficulty biting through clothing because of their short mouthparts, so even an untreated BDU can provide considerable protection.

VII. Other Diseases of Potential Military Significance.

A. Leptospirosis. (Weil disease, Canicola fever, Hemorrhagic jaundice, Mud fever, Swineherd disease)

The spirochete bacterium *Leptospira interrogans* is the causative agent of this zoonotic disease. More than 200 serovars of *L. interrogans* have been identified, and these have been classified into at least 23 serogroups based on serological relationships. Common clinical features are fever with sudden onset, headache, and severe muscle pain. Serious complications can occur. Infection of the kidneys and renal failure is the cause of death in most fatal cases. The severity of leptospirosis varies greatly and is determined largely by the infecting strain and health of the individual. In some areas of enzootic leptospirosis, a majority of infections are mild or asymptomatic. The incubation period is usually 10 to 12 days after infection.

Disease Distribution. Leptospirosis is one of the most widespread zoonoses in the world, occurring in urban and rural areas of both developed and developing countries. Close association of humans, animals, soil and water facilitates the spread of leptospirosis to humans. Risk of infection in the Caribbean is year-round but is elevated during periods of heavy rainfall. An increase in leptospirosis occurred in Puerto Rico after a hurricane in 1996, so this disease should be considered when planning for disaster relief. Leptospirosis is also common in flood-prone areas.

Leptospirosis is probably enzootic throughout the Caribbean area and is a serious public health problem. Risk appears highest in Barbados, Dominica, Jamaica, Martinique, St. Lucia, St. Vincent, and Trinidad and Tobago. Barbados has the most accurate data on the incidence of leptospirosis of any island in the English-speaking Caribbean, thanks to a *Leptospira* laboratory that was established on the island in 1979 (see website <http://www.users.sunbeach.net/users/levett/lepto.htm>). The annual incidence of severe leptospirosis until 1997 in Barbados was 12 cases per 100,000 population with a death rate of 13%. During a serosurvey between 1980 and 1983, 12.5% of Barbadian children and 9.5 % of Trinidadian children were seropositive for leptospiral antibodies. The morbidity of leptospirosis among children from Ciego de Avila Province, Cuba, was investigated from 1982 to 1995, and 253 cases were diagnosed.

Transmission Cycle(s). *Leptospira* infect the kidneys and are transmitted in the urine of infected animals. Humans become infected through contact of abraded skin or mucous membranes with contaminated water, moist soil or vegetation. Leptospira survive only in fresh water. In Barbados, the incidence of disease has been correlated with heavy rainfall and flooding. Spirochetes 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 rats. Infection from naturally infected meat or milk is uncommon. 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. Many human cases reported from the Caribbean are the result of occupational exposure. During a 1978 serosurvey, 45% of sugarcane workers in Trinidad had leptospiral antibodies.

Rodents and dogs are common reservoirs in the Caribbean. During surveys from 1994 to 1995, leptospires were isolated from 16% of *Rattus norvegicus* and *R. rattus* trapped at sites throughout Barbados. Leptospirosis is common in mongooses in Trinidad and Grenada. During the mid-1990s, seroprevalence in stray dogs was 62%. Similar results have been found during serosurveys of dogs in other islands of the Caribbean. The high seroprevalence in dogs is of public health importance due to the close contact between dogs and humans. In the early 1990s, 26% of the goats and 32% of the sheep tested on St. Croix, U.S. Virgin Islands, were seropositive for leptospiral antibodies. Similar results were obtained during serosurveys of goat herds on Jamaica. A high prevalence of leptospiral antibodies has also been observed in cattle, horses and pigs. Strains of leptospirosis pathogenic to humans have been isolated from the marine toad, *Bufo marinus*, and from the whistling frog, *Eleutherodactylus johnstonei*, on the island of Barbados. High levels of leptospiral antibodies have also been found in vervet monkeys, *Cercopithecus aethiops sabaeus*, on Barbados. However, studies have concluded that vervet monkeys were transmitting leptospiral infections among themselves and are not a significant source of human leptospirosis. Populations of vervet monkeys on St. Kitts and Nevis and Barbados islands are probably descendants from pets brought by African slave traders in the seventeenth century.

Disease Prevention and Control. To prevent leptospirosis, domestic rodents need to be controlled around living quarters and in food storage and preparation areas. Leptospires are readily killed by detergents, desiccation, acidity, and temperatures above 60°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 or adopting stray dogs or cats as pets. Leptospirosis could be a problem following flooding of contaminated streams or rivers. Vaccines have been used effectively to protect workers in veterinary medicine, and immunization has also been used to protect against occupational exposure to specific serovars in Japan, China, Korea, Italy, Spain, France and Israel. The *Leptospira* whole cell vaccine currently used in China is considered safe and effective, but the duration of protection conferred by this vaccine is only six months to one year. Short-term prophylaxis may be accomplished by administration of antibiotics. Doxycycline was effective in Panama in preventing leptospirosis in military personnel.

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 are allergenic. Reactions to arthropod bites and 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 regions 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. The anxiety produced in a fearful individual by a potential encounter with an insect 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 to situations that involve potential danger or require caution. Phobias, however, are characterized by persistent, high levels of anxiety in situations of little or no 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 the Caribbean:

1. Acari (mites and ticks). Scabies is the most important disease caused by mite infestation, and infestations have been common during military conflict. During World War I, scabies infestations occurred at a rate of 20 per 1,000 soldiers per year among American forces in Europe. During World War II, nearly 100,000 cases were reported in American troops. Five percent of the residents of London became infested with scabies during the bombing of the city by the German Air Force. During the Falklands War of 1982, scabies became such a problem among Argentine troops that their fighting efficiency was significantly impaired.

Sarcoptes scabiei (family Sarcoptidae) is a parasitic mite that spends its entire life cycle in burrows in the skin of mammals. Mite infestations cause scabies in man and mange in other animals, including primates, horses, wild and domestic ruminants, pigs, camels, rabbits, dogs and other carnivores. Populations found on different host species differ physiologically more than morphologically and are referred to as forms (those on man, for instance, are *S. scabiei* form *hominis*). Some authors may refer to forms as varieties or even subspecies. All forms are considered to be the same species, *S. scabiei.*

Mites from one host species rarely establish themselves on another. Humans can become infested with scabies mites from horses or dogs, but such infestations are usually mild and disappear without treatment. *Sarcoptes* mites are common on domestic animals in the Caribbean, especially stray dogs, so troops should avoid contact with local animals.

Scabies mites principally burrow in the interdigital and elbow skin, but skin of the scrotum, breasts, knees and buttocks may also be infested. The face and scalp are rarely involved. Scabies mites are very small, about 0.2 to 0.4 mm. Both sexes burrow in the horny layer of the skin, but only the female makes permanent burrows parallel to the skin surface. Burrowing may proceed up to 5 mm per day, and the burrow may extend over a cm in length. Mites feed on liquids oozing from dermal cells that have been chewed. Females lay 1 to 3 eggs per day in their tunnels and rarely leave their burrows. Eggs hatch into six-legged larvae that crawl out of the burrows onto the surface of the skin. Larvae burrow into the skin or a hair follicle and form a pocket in which they molt into the nymphal stage. Nymphs molt into adults, and the male burrows into the molting pocket in the skin and mates with the female. The female begins to burrow through the skin only after fertilization. Adult males can be found in short burrows or pockets in the skin or wandering around on the skin surface. The life cycle from egg to adult takes about 10 to 14 days. Adult females live about a month on humans but survive only a few days off the host. Clothing or bedding kept unused for about 5 days is usually free of mites.

Scabies is transmitted from person to person by close, prolonged personal contact. Transmission is common in dormitories, barracks and medical facilities. It is possible to get infested by sleeping in a bed formerly occupied by an infested person, but experimental work has indicated this rarely happens. Exposure for ten minutes at 50°C will kill mites. In newly infested persons, a period of 3 to 4 weeks usually elapses before sensitization to mites and mite excretions develops. Itching is not experienced during this period, and infestations may progress extensively before being noticed. However, fewer than 20 mites are enough to produce intense itching, particularly at night. The burrows often become secondarily infected with bacteria causing pustules, eczema and impetigo. In infested persons, an extensive rash can cover areas where there are no mites, and a rash may persist for several weeks after all scabies mites have been killed. In immunocompromised individuals, who do not respond to infestation by itching and scratching, mites can reach very high populations and produce a scaly crusted skin known as Norwegian or crusted scabies. With a highly contagious condition like scabies it is important to treat all persons living in close association with an infested individual.

Persons of all ages are affected, although in most developing countries infestation is highest in poor communities and in children. Infestation is more common in overcrowded areas with poor hygiene, and incidence increases during wars and natural disasters. Scabies is not a reportable disease in most countries; thus, estimated rates of infestation are usually inaccurate. Scabies is usually only reported when large outbreaks occur. Increases in the incidence of scabies appear to occur in 15 to 20 year cycles that are related to fluctuating levels of immunity to *S. scabiei* in the human population. Scabies is common among impoverished populations of the Caribbean. During the mid-1980s, epidemic scabies occurred on Trinidad, Tobago, Grenada, Dominica, the Turks and Caicos Islands, and St. Lucia.

Crusted or Norwegian scabies has been reported from Jamaica and Cuba. Scabies has been acquired by tourists that had contact with Cuban prostitutes.

Larvae of the mite family Trombiculidae, known variously as chiggers, harvest mites and 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 attack humans. Larvae are very small, measuring about 0.25 mm long, and are often called red bugs. Females lay eggs in damp 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. Chigger larvae do not burrow into the skin as commonly believed, nor do they feed primarily 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 leading to pustules and sometimes to secondary infection. In the tropics, the life cycle is completed in about 40 days and there is more than one generation per year, but in temperate zones there is one annual generation. *Eutrombicula alfreddugesi*, the American chigger mite (also called thalzahuatal and bicho colorado), commonly attacks humans in the eastern provinces of Cuba and other parts of the Caribbean.

Tick paralysis is a potentially fatal but easily cured affliction of man and animals. It is almost exclusively associated with hard (ixodid) ticks and is caused by injection of neurotoxin(s) in tick saliva. The toxin, which may be different in different species, disrupts nerve synapses in the spinal cord and blocks the 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. A tick must be attached to its host for 4 to 6 days before symptoms appear. This condition is characterized by an ascending, flaccid paralysis, usually beginning in the legs. Progressive paralysis can lead to respiratory failure and death. Diagnosis simply involves finding the embedded tick, usually at the base of the neck or in the scalp. After tick removal, symptoms resolve within hours or days. However, if paralysis is advanced, recovery can take several weeks. No drugs are available for treatment.

Most tick bites are painless, produce only mild local reaction, and frequently go unnoticed. However, dermal necrosis, inflammation or even hypersensitivity reactions may occur within a few days of tick attachment. After tick removal, a reddened nodule may persist for weeks or months. Tick-bite wounds can become infected with *Staphylococcus* and other bacteria causing local cutaneous abscesses. The bite of some cave dwelling *Ornithodoros* spp. can be painful and produce red, crusted nodules or papules up to 1.5 cm in diameter. Tick toxicosis is a systemic reaction to tick saliva. Tick-bite anaphylaxis has rarely been reported, but studies in Australia suggest it is more common and potentially life threatening than tick paralysis. Tick removal and other personal protective measures against ticks are discussed in Appendix E.

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 because their chelicerae cannot penetrate human skin, or they have venom of low toxicity to humans. Only about a dozen species have been responsible for severe systemic envenomization in humans, although as many as 500 species may be capable of inflicting 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 in order to administer appropriate therapy. In the Caribbean the widow spiders, *Latrodectus* spp. (family Theridiidae), are responsible for significant local and systemic effects from envenomization.

The black widow, *L. mactans*, is widespread in the Caribbean. The brown widow, *L. geometricus* also occurs in the region. The black widow, also referred to as the hourglass, shoe button, or po-ko-mo spider, is more common in warm climates and more likely to be found in human habitations than other Caribbean widow spiders. Considerable variation in coloration and markings exists between species and between immatures and adults of *Latrodectus* spp. Widow spiders are found in various habitats, especially such protected places as crawl spaces under buildings, holes in dirt embankments, 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 these structures. Widow spiders spin a crude web and usually will not bite unless provoked. Females are more prone to bite when guarding the egg sac.

Latrodectus spp. inject a potent neurotoxin when biting. The bite itself is mild and most patients do not remember being bitten. Significant envenomization results in severe systemic symptoms, including painful muscle spasms, a rigid board-like abdomen, and tightness in the chest. Mortality rates from untreated bites have been estimated at 1 to 5%. Most envenomizations respond quickly to sustained intravenous calcium gluconate. Antivenins are commercially available and very effective.

Several species of *Loxosceles* spiders occur in the Caribbean. Members of this genus have 6 eyes arranged in a semicircle, unlike most spiders which generally have 8 eyes. Immediately behind the eyes is a characteristic violin-shaped marking on the cephalothorax that may be indistinct in some individuals. Adult females average about 10 mm in length, and the body color varies from light fawn to dark brown. A medium-sized, irregular web is constructed that extends in all directions. *Loxosceles* spiders are shy and inhabit secluded areas of the home, such as basements, closets, and boxes. People are commonly bitten when putting on old clothes or shoes that haven't been worn for long periods. Outdoors, recluse spiders may be found under rocks, bark, and tree limbs on the ground. Both sexes can bite, although males inject half as much venom as females. The venom is cytolytic and hemolytic. The bite may not be noticed for 2 or 3 hours, or a stinging sensation followed by intense pain may occur. The venom produces considerable necrosis that may ultimately leave an unsightly scar. This dermal necrosis is difficult to treat and may require 6 to 8 weeks to heal. Necrotic damage may be so extensive that skin grafting is required. Systemic reactions are uncommon but can be serious and life threatening.

Several species of tarantulas (family Theraphosidae) occur in the Caribbean that may attain a length of 15 cm. Despite their fearsome appearance, their bite, though locally painful, is essentially nontoxic. Their habits range from trap door species in Cuba to tree-dwelling species in Trinidad. The hairs of some species can cause dermatitis.

3. Ceratopogonidae (biting midges, no-see-ums, punkies). The Ceratopogonidae is a large family containing nearly 5,000 species in over 60 genera. These extremely small flies (1 to 2 mm) can easily pass through window screens and standard mosquito netting, although most species feed outdoors. Their small size is responsible for the moniker "no-see-ums." Many species in this group 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). Only females suck blood. In the Caribbean these insects transmit the filarial worm *Mansonella ozzardi* to humans, and they serve as vectors for several diseases of veterinary importance, such as blue tongue virus. Though ceratopogonids are widespread in the region, little is known about their biology. Many species of *Culicoides* are zoophilic. *Leptoconops* are more likely to be a major nuisance to man, although *C. furens* is the most widespread man-biting species in the Caribbean. Blood-sucking species chiefly feed and rest outdoors, entering houses in much smaller 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, these flies often cause local reactions severe enough to render 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 adult flies often emerge from breeding sites, causing intolerable annoyance. Most species remain within 500 m of their breeding grounds, although some species of *Culicoides* and *Leptoconops* are known to fly 2 to 3 km without the assistance of wind. Ceratopogonidae are troublesome mainly under calm conditions, and the number of flies declines rapidly with increasing wind speed.

Breeding habits vary widely from species to species. The larvae are primarily aquatic or semiaquatic, occurring in the sand or mud of fresh, salt, or brackish water habitats, notably salt marshes and mangrove swamps. Some important species breed in sandy areas near the seashore, where they can be a serious economic threat to the tourist industry. Larval densities as high as 10,000 per square meter have been recorded. There are 4 larval instars, and a fully grown larva is only about 5 to 6 mm long. In warm climates larval development is completed within 14 to 25 days. Many species exploit specialized habitats, such as tree holes, decaying vegetation, and cattle dung. In militarily secure areas, encampments should be located in the open, away from breeding sites, to avoid the nuisance caused by these insects.

Larvae are difficult to find, but adults are easily collected while biting and with light traps equipped with fine mesh netting. Environmental management best controls larval stages, 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 application of aerosols may produce temporary control, but sprayed areas are soon invaded by midges from unsprayed areas. Ceratopogonids have difficulty biting through clothing because of their short mouthparts, so even an untreated BDU can provide considerable protection.

4. Chilopoda (centipedes) and Diplopoda (millipedes). Centipedes in tropical countries can attain considerable size. Members of the genus *Scolopendra* can be over 25 cm long and are capable of inflicting painful bites, with discomfort lasting 1 to 5 hours. Several species of this genus occur in the Caribbean. *Scolopendra gigantea* is the species most frequently associated with human bites and occurs in northern Venezuela, Trinidad, Isla Margarita, Curaçao and Aruba. It reaches 27 cm in length. Records of this species from the U.S. Virgin Islands and Haiti probably represent accidental importations. *Scolopendra* bites produce excruciating local pain, erythema and swelling. Centipedes bite using their first pair of trunk appendages (maxillipeds), which have evolved into large, claw-like structures. Two puncture wounds at the site of attack characterize a centipede bite, and they are sometimes confused with the bite marks of a viper. Neurotoxic and hemolytic components of a centipede's venom normally produce only a localized reaction, but generalized symptoms such as vomiting, irregular pulse, dizziness and headache may occur. Most centipede bites are uncomplicated and self-limiting, but secondary infections can occur at the bite site. Centipede bites are rarely fatal to humans.

Centipedes are flattened in appearance and have 1 pair of legs per body segment. Large species may have over 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. Centipedes are not aggressive and seldom bite unless molested. Most centipede bites occur when the victim is sleeping or when putting on clothes in which centipedes have hidden. Troops should be taught to inspect clothing and footwear when living in the field.

Millipedes are similar to centipedes except that they have two pairs of legs per body segment and are rounded or cylindrical instead of flattened. Millipedes are commonly found under stones, in soil and in leaf litter. They are nocturnal and most species feed on decaying organic matter. They are more abundant during the wet season. When disturbed they coil up into a tight spiral. Millipedes do not bite or sting, but some species secrete defensive body fluids containing quinones and cyanides that discolor and burn 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 a distance of 80 cm or more.

5. Cimicidae (bed bugs). There are over 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 for centuries and is cosmopolitan in distribution. 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 America. Some species that are parasites of bats or birds, especially pigeons, may occasionally bite humans in the absence of their normal hosts. Bed bug infestations are typical of unsanitary conditions, but they can still be found in developed countries. There is little evidence that bed bugs transmit any pathogens. Bites can be very irritating, prone to secondary infection after scratching, and may produce hard swellings or welts. Bed bugs feed at night while their hosts are sleeping but will feed during the day if conditions are favorable. During the day they hide in cracks and crevices, under mattresses, in mattress seams, spaces under baseboards, or loose wallpaper. Chronic exposure to bed bugs can result in insomnia, nervousness and fatigue. Some studies have found that a high percentage of asthmatic patients have positive skin reactions to *Cimex* antigen.

Five nymphal instars precede the adult stage. Each nymph must take a bloodmeal in order to molt. Adults live up to 1 year. Bed bugs take about 5 minutes to obtain a full bloodmeal. They can survive long periods of time without feeding, reappearing from their hiding places when hosts become available. Females may live several months and lay 50 to 200 eggs over their lifetime. Bed bugs possess scent glands and emit a characteristic odor that can easily be detected in heavily infested areas. Blood spots on bedding or "bedclothes" and fecal deposits are other signs of infestation. Eggs and cast nymphal skins may be observed in cracks and crevices.

Infestations of bed bugs in human habitations are not uncommon in some areas of the Caribbean. Bed bugs can be introduced into barracks through infested baggage, bedding and belongings. They may pass from the clothing of one person to another on crowded public vehicles. In the absence of humans, bed bugs will feed on rats, mice, bats or birds. Therefore, old dwellings should be surveyed for these and other pests before they are occupied during contingency situations. *Cimex 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 and 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*, *Chrysomyia*, *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* are commonly called bluebottle flies because of their metallic-bluish or bluish-black color. The abdomen is usually shinier than the thorax. The family Sarcophagidae, known as flesh flies, contains over 2,000 species, but the only important genera in terms of myiasis are *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, depositing first-instar larvae instead of eggs. The larvae are deposited in batches of 40 to 60 on decaying carcasses, rotting food, and human or animal feces.

Myiasis is 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 results from ingesting fly eggs or young maggots on uncooked foods or previously cooked foods that have been subsequently infested. Other cases may stem 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 the Caribbean. Surgeons used maggots that feed only on necrotic tissues to clean septic battle wounds until about the 1950s. 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 sheep bot fly, *Oestrus ovis*, is found wherever sheep are raised. Larvae are obligate parasites in the nostrils and frontal sinuses of sheep, goats, camels and horses and commonly attack humans. Human ocular infestation by *O. ovis* has been reported from the Caribbean. Several cases occurred in U.S. military personnel during the Persian Gulf War. Female flies are larviparous, depositing larvae directly into the human eye while in flight. Normally, infestations produce a painful but not serious form of conjunctivitis. However, larvae are capable of penetrating to the inner eye, causing serious complications.

Dermatobia hominis (tórsalo or human bot fly) parasitizes humans, cattle, dogs, and a number of other wild and domestic mammals and birds. It occurs throughout Central and South America, where it is often a serious pest of cattle. In the Caribbean, the human bot fly has been found on Trinidad. The female adopts a unique method of transporting her eggs to the host. Eggs are cemented on day-flying mosquitoes, flies or, rarely, on ticks that attack a warm-blooded host. The warmth of the host induces the larva to emerge from the egg and penetrate the host's skin. At the site of penetration, a small nodule of host tissue develops around each larva, with a central breathing pore. The larva feeds for 6 to 12 weeks in humans, then when mature emerges and drops to the ground to pupate. The cutaneous swellings can be itchy and painful but are not serious unless infected. The head is a common site of infestation. Should larvae enter the eye, a serious ophthalmomyiasis can result in eye loss or, rarely, fatal brain damage in children. Tourists in endemic areas are frequently infested but may not notice the nodule until they return home.

The New World screwworm, *Cochliomyia hominivorax*, attacks, humans, cattle, horses, sheep, goats, pigs, dogs, and many species of wildlife. The screwworm causes enormous livestock losses but has been eradicated from the U.S. and many other areas using the sterile insect technique. *Cochliomyia hominivorax* has occurred periodically throughout the Caribbean, where it has frequently parasitized humans. It is a true obligate parasite of mammals. Rather than laying eggs on carrion, female flies oviposit at the edges of wounds on living mammals, or on mucous membranes associated with the nostrils and sinuses, eye orbits, mouth, ears and vagina. Females lay on average 200 eggs that hatch within 24 hours of being laid. As the larvae feed, the wound is deepened and enlarged, resulting in extensive tissue destruction. Infested wounds are attractive to other female flies that lay additional batches of eggs. After larvae reach maturity in 5 to 7 days, they fall to the ground, where they burrow and pupate.

Myiasis is rarely fatal, but troops living in the field during combat are at 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. Personnel should 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 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 for subduing 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 primarily 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. It is also important to remove the stinger as quickly as possible since an alarm pheromone is emitted at the base of the sting that attracts other bees. Honey bees and social wasps of the family Vespidae account for most stings requiring medical treatment in the Caribbean. Wild strains of honey bees may be more aggressive than domesticated populations maintained by bee keepers. The Africanized honey bee has spread from South America into the southwestern U.S. A near-fatal case due to stings of the Africanized bee has been reported from Trinidad. This aggressive honey bee may spread to other islands of the Caribbean from Central and South America. There is some evidence that the repellent deet can be effective in repelling the Africanized honey bee if used as an aerosol spray during an attack.

Ants are extraordinarily abundant in the tropics. They can bite, sting and squirt the contents of their poison gland through the tip of the abdomen as a defensive secretion. 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. Several species of fire ants occur in the Caribbean. Fire ants in the genus *Solenopsis* produce large colonies in excess of 200,000 workers that aggressively defend their nest. Nearly 100 species of *Solenopsi*s occur in the American and Caribbean tropics. Stings are painful and result in pustules and necrotic lesions. *Solenopsis invicta*, the imported red fire ant, occurs in Puerto Rico and Cuba, where it is called the hormiga de fuego. *Solenopsis geminata* is another common species in the Caribbean. The little fire ant, *Wasmannia auropunctata*, has become established in Puerto Rico, where it is a serious pest and is called the abayalde. 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 venoms, although cross-reactivity may exist to some extent between different vespid venoms. Therefore, a person sensitized to one vespid venom could have a serious reaction to the sting of another member of the vespid 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 at the sting site that subsides in a few hours. Stings in the mouth or throat may require medical assistance. Multiple stings in a short period of time may cause systemic symptoms such as nausea, malaise and fever. It generally takes 500 or more honey bee stings to kill an adult by the toxic effects of the venom alone. The toxicity of Africanized honey bee venom is roughly equivalent to that 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.

Delayed reactions to Hymenoptera envenomization are uncommon but usually present as a large local swelling or, rarely, as systemic syndromes. The cause of delayed reactions is unclear and may not always involve immunologic mechanisms.

Individuals can practice 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 (urticating moths and caterpillars). The caterpillars of certain moths possess urticating hairs that can cause dermatitis as well as systemic reactions affecting the joints and other parts of the body. The hairs are usually connected to glands that release poison when the hair tips break in human skin. The intensity of the irritation varies with the species of moth, sites and extent of exposure, and the sensitivity of the individual, but usually the symptoms are temporary. 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. Larvae of the families Saturniidae (giant silkworm moths), Megalopygidae (flannel moths) and Limacodidae (shag moths) are most often associated with urticaria in the Caribbean. Flannel moth caterpillars are often brightly colored and so densely covered with hairs that they have a furry appearance that may invite handling. However, beneath the hairs are stinging spines that cause severe irritation.

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 help relieve itching and burning sensations.

9. Meloidae (blister beetles), Oedemeridae (false blister beetles) and Staphylinidae (rove beetles). Blister beetles are moderate-sized (10 to 25 mm in length), soft-bodied insects that produce cantharidin in their body fluids. Cantharidin is a strong vesicant that readily penetrates the skin. Handling or crushing the beetles causes blistering within a few hours of skin contact. There is a large variation in individual susceptibility to blistering from cantharidin. Blisters are generally not serious and normally clear within 7 to 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 antiseptics. Cantharidin was once regarded as an aphrodisiac, and a European species of blister beetle was popularly known as Spanish-fly. Troops should be warned against using blister beetles for this purpose, since cantharidin is highly toxic when taken orally.

Approximately 1,500 species of Oedemeridae are found worldwide. They are slender, soft-bodied beetles, 5 to 20 mm in length. The adults of most species feed on pollen, so they are commonly found on flowers, but oedemerids are also readily attracted to light. 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 of 531 soldiers developed blistering after exposure to *Thelyphassa lineata*.

The Staphylinidae, commonly called rove beetles, is another family that produces a strong vesicating substance that causes blistering. Rove beetles are active insects that run or fly rapidly. When running, they frequently raise the tip of the abdomen, much as scorpions do. They vary in size, but the largest are about 25 mm in length. Some of the larger rove beetles can inflict a painful bite when handled. Many species are small (<5 mm) and can get under clothing or in the eyes. Members of the genus *Paederus* are found throughout the world, including the Caribbean. 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 the vesicating agent. Like beetles in the family Meloidae, rove beetles are attracted to light and readily enter houses or other buildings at night. They can be a hazard to soldiers at guard posts. Rove beetles often emerge in large numbers after rains and can cause outbreaks of dermatitis. A 1966 outbreak of blistering on Okinawa resulted in 2,000 people seeking medical treatment.

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. All species of scorpions are poisonous. However, of over 1,400 described species worldwide, fewer than 25, all in the family Buthidae, possess a venom that is life threatening to humans. Most produce a reaction in humans comparable to a bee sting. Besides stinging, some species can inflict a painful pinch with their pedipalps. Scorpions feed at night on insects, spiders and other arthropods. During the daytime, they hide beneath stones, logs or bark, loose earth or among manmade objects. In dwellings, scorpions frequently rest in shoes or clothing.

Scorpions use their sting to capture prey, for defense against predators, and during mating. The venom sacs are controlled voluntarily, so a scorpion can regulate how much venom is injected with each sting. Some scorpions may not inject any venom while stinging. Scorpion venom is a complex mixture of substances that may include several neurotoxins, histamine, serotonin, enzymes, and 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 indicating 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 the Caribbean. The scorpions *Centruroides gracilis*, *C. griseus*, *Tityus obtusus*, and *T. trinitatis* are medically important and occur on Cuba, Martinique, Puerto Rico, Trinidad and Tobago, and possibly other islands as well. Their venom may cause a variety of painful symptoms in humans, including acute heart problems, cardiac histopathology, and pancreatic or neurological involvement. Severest symptoms occur in small children and the elderly. However, cardiac problems are not limited to these age groups. Most scorpion stings do not require hospitalization, and death is rare. The scorpions of the genus *Centruroides*, found throughout the Carribean, are toxic enough that antivenoms are commercially produced and sold for treatment of stings. Some scorpions appear to be widespread in the Caribbean, possibly because they have reached other islands via waterborne debris moved by ocean currents and storms, or were introduced by inter-island commerce. Geographic isolation has led to the evolution of species known only from a single island or island group.

Most scorpion stings are to the lower extremities or the arms and hands. Among indigenous populations, stings are more often inflicted at night, while scorpions are actively hunting for prey. Scorpion stings can occur year-round in the Caribbean. Scorpions can sting multiple times, and when 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 involvement 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. The clinical management of scorpion envenomations is controversial. 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. Only in rare cases do symptoms extend beyond 72 hours. 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 attempting to put them on, to carefully inspect clothing left on the ground before putting it on, and to keep sleeping bags tightly rolled when not in use. Also, troops must be cautioned that scorpions can cause painful reactions requiring medical treatment and should never be kept as pets, handled or teased.

Table 2. Distribution of Scorpions in the Caribbean (+ = present; ? = uncertain)

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
BUTHIDAE																								
Alayotityus granma								+																
A. juraguaensis								+																
A. nanus								+																
A. sierramaestrae								+																
Ananteris cussinii																						?	+	
Centruroides alayoni										+				?										
C. anchorellus								+																
C. arctimanus								+																
C. bani										+				?										
C. barbudensis	+			+									+	+		+								
C. gracilis								+								+								
C. griseus																	+							+

Table2. continued

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
C. guanensis								+																
C. insulanus															+									
C. jaragua										+				?										
C. luceorum										?				+										
C. marconoi										+				?			+							
C. margaritatus										+					+									
C. n. nitidus										+				+			+							+
C. n. tairo										+														
C. pococki										+			+	+						+				+
C. robertoi								+																
C. testaceous		+							+				?							?				
C. underwoodi															+									

Table 2. continued

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
Isometrus maculatus								+					+				+			+				+
Microtityus consuelo										+				?										
M. dominicanensis										+				?										
M. fundorei								+																
M. guantanamo								+																
M. iviei										+				?										
M. jaumei								+																
M. lantiguai										+				?										
M. paucidentatus										+				?										
M. rickyi																						?	+	
M. starri																						+	+	
M. trinitensis								+																
M. virginiae										+				?										
M. waeringi										+				?								?	?	+

Table 2. continued

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
Rhopalurus abudi										+				?										
R. bonnetti										+				?										
R. garridoi								+																
R. junceus								+																
R. princeps								+		+				+										
Tityopsis inaequalis								+																
T. inexpectatus								+																
Tityus altithronus										+				?										
T. atriventer											+													
T. bellulus										+				?										
T. crassimanus										+				+	+									
T. d.dasyurus																	+							+
T. discrepans																							+	
T. ebanoverde										+				?										

Table 2. continued

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
T. elii										+				?										
T. exstinctus																+								
T. insignis																				+				
T. melanostictus																						+	+	
T. michelii															+									
T. neibae										+				+										
T. obtusus																	+							
T. ottenwalderi										+				?										
T. p. pictus					+										+						+			
T. p. microdon												+				+								
T. p. smithii											+	+				+								
T. portoplatensis										+				?										
T. quelchii																							+	

Table 2. continued

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
T. quisqueyanus								+		+				?										
T. trinitatis																						+	+	
CHACTIDAE																								
Broteochactas laui																						+	+	
B. nitidus																						+	+	
Chactas raymondhansorum																						+	+	
DIPLOCENTRIDAE																								
Cazierius alayoni										+				+										
C. dominicus										+				?										
C. g. gundlachii								+																
C. g. parvus								+																
C. monticola										+				?										
C. politus										+				?										

Table 2. continued

Scorpion Species	**Antigua**	**Aruba**	**Barbados**	**Barbuda**	**Bequia**	**Bonaire**	**Cayman Islands**	**Cuba**	**Curaçao**	**Dominican Republic**	**Grenada**	**Grenadines**	**Guadeloupe**	**Haiti**	**Jamaica**	**Martinique**	**Puerto Rico**	**Saba**	**St Kitts**	**St Lucia**	**St Vincent**	**Tobago**	**Trinidad**	**Virgin Islands**
C. scaber			+																					
Didymocentrus hasethi									+															
D. hummelincki						+																		
D. lesueurii																+				+				
D. minor																					+			
D. trinitarius								+																
D. waeringi											+													
Heteronebo b. bermudezi								+																
H. b. morenoi								+																
H. caymanensis							+																	
H. cicero										+				**?**										
H. dominicus										+				**?**										

Table 2. continued

Scorpion Species	Antigua	Aruba	Barbados	Barbuda	Bequia	Bonaire	Cayman Islands	Cuba	Curaçao	Dominican Republic	Grenada	Grenadines	Guadeloupe	Haiti	Jamaica	Martinique	Puerto Rico	Saba	St Kitts	St Lucia	St Vincent	Tobago	Trinidad	Virgin Islands
H. elegans															+									
H. franckei															+									
H. j. jamaicae															+									
H. j. occidentalis															+									
H. j. portlandensis															+									
H. nibujon								+																
H. portoricensis																	+							
H. pumilus														+										
H. vachoni																+								
H. yntemai																								+
Oieclus p. purvesii	+			+						+				+					+					
O. p. sabae																		+						

Table 2. continued

Scorpion Species	**Antigua**	**Aruba**	**Barbados**	**Barbuda**	**Bequia**	**Bonaire**	**Cayman Islands**	**Cuba**	**Curaçao**	**Dominican Republic**	**Grenada**	**Grenadines**	**Guadeloupe**	**Haiti**	**Jamaica**	**Martinique**	**Puerto Rico**	**Saba**	**St Kitts**	**St Lucia**	**St Vincent**	**Tobago**	**Trinidad**	**Virgin Islands**
ISCHNURIDAE																								
Opisthacanthus lepturus										+				+				+						
IURIDAE																								
Hadrurus parvulus								+																

11. **Simuliidae (black flies, buffalo gnats, turkey gnats).** Over 1,600 species of black flies have been described. Taxonomy and identification of species are difficult, since species complexes are unusually prevalent in the family Simuliidae. Only species in the genus Simulium are medically important in the tropics. Black flies are small (3 to 5 mm), usually dark, stout-bodied, hump-backed flies with short wings. Despite their appearance, black flies are strong flyers, and some species are capable of dispersing up to 30 km from their breeding sites. Only females suck blood, although both sexes feed on plant juices and nectars. They can emerge in large numbers and be serious pests of both livestock and humans. A characteristic of many species is the mass emergence of thousands of adults during a short period. The time taken from egg to adult can be as little as 2 weeks in some tropical species, and 15 to 20 generations can be produced in a year. Black flies 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. Some species feed exclusively on birds and others on mammalian hosts. The arms, legs and face are common sites of attack, and a favorite site is the nape of the neck. Black fly bites are painful and may be itchy and slow to heal. Systemic reactions, characterized by wheezing, fever or widespread urticaria, are rare but require medical evaluation and treatment. Black fly larvae usually require clean, flowing water but may be common in or near urban areas. *Simulium quadrivittatum* is a major pest species in the Caribbean.

12. Siphonaptera (fleas). Flea bites can be an immense source of discomfort. The typical flea bite consists of a central spot surrounded by an 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 flea bites. 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 habitat. 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 fleas. The most common pest fleas encountered in the Caribbean are the cosmopolitan cat and dog fleas, *Ctenocephalides felis* and *C. canis*, the Oriental rat flea, *Xenopsylla cheopis*, and the human flea, *Pulex irritans*. Occasionally, fleas parasitizing birds nesting in human dwellings may bite humans in the absence of their avian hosts.

Tunga penetrans is also known as the chigoe, jigger, chigger, chique or sand flea. The chigoe is a tiny (about 1 mm long) flea that is native to Latin America and the Caribbean. It was probably introduced into Africa in the seventeenth century and rapidly disseminated by expeditions throughout tropical Africa. Indian laborers and troops returning to their homeland from Africa carried the parasite to Bombay, and later to Karachi, Pakistan. High rates of morbidity caused by *T. penetrans* were observed among soldiers during the East African campaign of World War I and the Ethiopian campaign of World War II. Chigoes are highly endemic in southwestern Trinidad, where 20% of 1,307 residents were infested during a 1997 survey of five townships. At least 7 species of bacteria, some resistant to antibiotics, were isolated from patients with infections caused by *T. penetrans*.

Infestation with this flea is commonly referred to as tungiasis. The fertilized female cuts the host skin with her mouthparts and inserts her head and body until only the last 2 abdominal segments are exposed. The gravid female may become as large as a pea. Females feed and periodically deposit eggs. Most eggs fall to the ground and hatch, but a few may hatch within the nodular swelling of the host skin before falling to the ground. Over 1,000 eggs may be produced. When the female flea dies, she remains embedded in the skin where the dead flea produces inflammation and ulcers. Larval development is completed within 2 weeks under favorable conditions. *Tunga penetrans* usually attacks humans between the toes, under the toenails and on the soles of the feet. Infestations may also occur on the hands and arms, particularly around the elbow, and in the genital region. Attached fleas cause extreme irritation. Ulcerations due to the presence of numerous chigoes may become confluent. Tetanus and gangrene may result from secondary infection, and autoamputation of toes has been recorded. *Tunga penetrans* will also attack other animals, including dogs, rodents, and especially swine. Where the chigoe occurs, walking in bare feet should be avoided. *Tunga penetrans* commonly occurs in sandy soil, and infestations are frequently acquired by tourists walking barefoot along sandy beaches in some parts of the Caribbean. Attached fleas should be immediately removed with a sterile needle or fine-pointed tweezers.

13. Solpugida (sun spiders, wind scorpions). These arthropods inhabit tropical and subtropical desert environments in Africa, Asia, Europe, and the Americas. They usually avoid fertile, highly vegetated places, seeming to prefer utterly neglected regions where the soil is broken and bare. Their hairy, spider-like appearance and ability to run rapidly across the ground account for their common names. Sun spiders range from 20 to 35 mm in body length and are usually pale colored. They have very large, powerful chelicerae, giving them a ferocious appearance. They can inflict a painful bite but do not have venom glands. Sun spiders are largely nocturnal, hiding during the day under objects or in burrows. They are aggressive and voracious predators on other arthropods. They easily kill scorpions and may even capture small lizards. At night they sometimes enter tents to catch flies or other insects.

14. 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. The larvae develop in moist or semiaquatic sites, such as the margins of ponds, 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 prolonged, and many species spend 1 to 2 years as larvae. In temperate regions the entire life cycle can take 2 years or more to complete. The larvae of horse flies 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, about 8 to 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* species, also known as clegs or stouts, are not found in South America or Australia, and only a few species occur in North America. However, they are common in Europe, Africa and Asia.

Only female tabanids bite and take a bloodmeal, and nearly all species feed on mammals. Males feed on flower and vegetable juices. Tabanids are diurnal and 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 km. 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. Because of their preference for dark objects, they tend to bite through colored clothing rather than light- colored skin. Their large mouthparts enable them to penetrate many types of clothing.

Tabanids lacerate the skin with scissor-like mouthparts and ingest the blood that flows into the wound. Some species can consume as much as 200 mg of blood. The puncture in the skin 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 the 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 the Caribbean, tabanids are not vectors of human disease 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. Similar problems are encountered in the control of ceratopogonid larvae. 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 these flies.

B. Venomous Snakes of the Caribbean.
Bothrops lanceolatus, also known as the lancehead or fer-de-lance, is the most familiar of the Caribbean poisonous snakes. Adults of this species average 1.5 to 2.5 m in length, with some individuals attaining a length of 3.5 m. The head is brown with a distinct postorbital band that extends to the corner of the mouth. The ventral surface is white or cream-colored, while the dorsal surface is covered with an obscure series of brown-gray or olive hourglass-shaped blotches. This species feeds on both birds and rodents but prefers rodents. *Bothrops lanceolatus* will feed opportunistically on other animals, such as frogs, toads, crabs and lizards. The bite of this snake is serious and produces swelling, pain, discoloration, hemorrhage, thrombosis, necrosis, hypotension and, occasionally, respiratory distress.

Bothrops asper is a medium-sized snake that averages 2 to 3 m in length. This species is olive-green to gray or brown and has a bilateral series of black-edged triangles whose apices meet at the vertebral line. It is widespread and occurs in forested areas of Trinidad, including banana, coffee and cacao plantations, often living along streams. *Bothrops asper* may become aggressive if disturbed and will strike repeatedly. It feeds on small rodents, lizards and frogs.

Bothrops caribbaeus is a small pale gray or yellow-gray pit viper that occurs only on St. Lucia, where it inhabits forested areas, including coconut and cacao plantations. It exhibits body blotches just slightly darker than the grayish or yellowish color of the snake. This species averages just 1 to 1.5 m in length. *Bothrops caribbaeus* is a dangerous snake whose bite causes serious local tissue necrosis around the bite site.

Crotalus durissus, the cascabel, is the only true rattlesnake in the region and occurs only on Aruba and possibly Trinidad. This stout, medium-sized snake exhibits a series of large rhombic black diamonds down the dorsum of the body, which is otherwise brown to olive in color. A subspecies of this snake, *C. durissus unicolor*, occurs on Aruba and is light gray to gray-brown, with rhombic diamonds that are only faintly distinguishable along the vertebral line. The neck is distinctive in that it exhibits a pair of dark stripes. *Crotalus durissus* occurs in dry areas, such as grasslands and thorny scrub habitat. The cascabel rattlesnake is one of the most dangerous snakes in the Caribbean because its venom produces serious systemic reactions, including blindness, paralysis of the neck muscles, respiratory arrest, and serious heart complications that may cause death. The Aruba subspecies is less dangerous because of its small size.

The genus *Micrurus* includes the American coral snakes, such as *Micrurus lemniscatus* and *M. psyches*. These are small-headed snakes, with the head indistinct from the body. The body is elongated and slender, untapered and possesses a very short tail. The eyes are small and have round pupils. The body is distinctly colored in rings of yellow, black and red. There are two relatively large tubular fangs. *Micrurus* spp. are rarely able to sink their fangs deep into a human and inject a large quantity of venom due to the small size of the head and short body length (not exceeding 1.5 m). This reduces the mortality and morbidity of bites, although the venom is very toxic.

The bushmaster, *Lachesis muta*, has occasionally been reported on Trinidad and Tobago, although this would only be a minor extension of its primary distribution in Central and South America. This is a large tan to brown snake with dark brown rhomboid patterns along the back. There is a peculiar burr of pointed spines near the tip of the tail. This species averages 1.5 to 2.5 m in length but may attain a length in excess of 3 m. *Lachesis muta* is potentially dangerous because of its long fangs and the large amounts of toxic venom that may be injected. However, its strictly nocturnal behavior limits encounters with humans.

The jubo, *Alsophis cantherigerus*, is a rear-fanged colubrid snake found in Cuba. This species has saliva that causes a severe localized reaction at the bite site consisting of lesions, painful swelling, rash and irritation. The bite of the West Indian racer, *Alsophis portoicensis*, has similar toxic effects. This snake feeds mainly on frogs and other snakes by wiggling its grub-like tail as a lure and subduing the prey with its toxic saliva.

Table 3. Distribution of Venomous Terrestrial Snakes in the Caribbean (+ = Present; ? = Uncertain)

Species	Aruba	Cuba	Martinique	Puerto Rico	St. Lucia	Trinidad and Tobago
COLUBRIDAE						
Alsophis cantherigerus		+				
A. portoricensis				+		
ELAPIDAE						
Micrurus lemniscatus						+
M. psyches						+
VIPERIDAE						
Bothrops asper						+
B. caribbaeus					+	
B. lanceolatus			+			
Crotalus durissus	+					?
C. d. unicolor	+					
Lachesis muta						+

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.

Members of the *Rhus* group (poison ivy, oak, and sumac) are the most frequent causes of acute allergic contact dermatitis. 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 be contaminated with urushiol and cause dermatitis in a sensitive person who touches the object. Even smoke from burning plants can produce a severe allergic response. Barrier creams have been developed to prevent contact dermatitis in people sensitive to urushiol but are only partially effective. Allergy to poison ivy, oak and sumac may also mean a person is allergic to related plants, including cashews, pistachios, mangos and Chinese or Japanese lacquer trees (*Toxicodendron verniciflua*). The mango, *Mangifera indica*, is widely grown in the Caribbean.

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

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

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 of some *Euphorbia* spp. is highly irritating and may cause blindness if it contacts the eyes.

Mechanical injury by splinters, thorns, spines and sharp leaf edges can produce visual impairment or fungal and bacterial infections at the site of injury. Plant thorns and spines may introduce infective microorganisms, including *Clostridium tetani*, into the skin and sub- cutaneous 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 other body cavities. Many bulbs and some plants, notably *Dieffenbachia*, the popular house plant known as dumb cane, contain calcium oxalate. This waterinsoluble salt forms bundles of needle-like crystals that can cause severe irritation when they become embedded in the skin or mucosae. Plant juices containing calcium oxalate cause severe pain when splashed into the eyes and large numbers of calcium oxalate crystals may penetrate the cornea.

There are few medical reports of plant dermatitis from the Caribbean. Except for introduced species, little is known about the medical properties of many native plants. Plants causing dermatitis in the Caribbean include:

Abrus precatorius	*Euphorbia* spp.
Acaea spp.	*Hippomane mancinella*
Agave spp.	*Hura crepitans*
Ammannia spp.	*Jatropha* spp.
Argemone spp.	*Lantana camara*
Calophyllum inophyllum	*Malpighia* spp.
Calotropis spp.	*Mangifera* spp.
Cameraria spp.	*Metopium* spp.
Chlorophora spp.	*Rhus* spp. *(Toxicodendron* spp.*)*
Colocasia spp.	*Ricinus communis*
Comocladia spp.	*Schinus* spp.
Croton spp.	*Sterculia* spp.
Dalechampia spp.	*Thevetia* spp.
Daphne spp.	*Tragia* spp.
Datura spp.	*Urea* spp.
Duranta erecta (D. repens)	

For additional information on plants causing dermatitis, contact DPMIAC.

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 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 resin in the plant can cause severe dermatitis. The cashew nut shell, but not the kernel, contains a brown oily juice that is a contact allergen. Roasting the shell liberates irritating vapors. In India, where cashews are grown commercially, cashew nut dermatitis often affects thousands of workers.

Many plants have fruiting bodies or have attractive parts that appear edible. *Ricinus communis*, the castor oil plant, has highly ornamental, oval seeds. Castor oil is derived from the seeds. 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 prevents absorption and therefore inhibits poisoning, but 2 to 6 beans can be fatal to an adult if well chewed. One or 2 seeds can be fatal to a child.

Seeds of *Abrus precatorius* (known variously as 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 rosaries or 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 berries are involved in most accidental poisonings. Only about 5 grams of leaves or seeds can be fatal 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 as poisonous. Just a few berries can kill a child. 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 as folk medicines or for other purposes. Local lore may attribute medicinal qualities, psychotropic or aphrodisiac effects to native plants. Marijuana (ganja), known also as hemp, *Cannabis sativa*, is widely grown and used in some parts of the Caribbean, especially Jamaica. The region is a major source of illicit trade in this illegal drug.

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.

Plants that cause systemic poisoning in the Caribbean include:

Abrus precatorius	*Karwinskia* spp.
Acteae spp.	*Lantana camara*
Ageratina altissima	*Manihot esculenta*
Aleurites spp.	*Melia* spp.
Barringtonia spp.	*Momordica* spp.
Blighia sapida	*Nerium* spp.
Calophyllum inophyllum	*Phytolacca* spp.
Calatropis spp.	*Pilocarpus* spp.
Cestrum spp.	*Rhus* spp. (*Toxicodendron* spp.)
Citrullus colocynthis	*Ricinus communis*
Colocasia spp.	*Sapium* spp.
Croton spp.	*Schinus* spp.
Saphne spp.	*Sesbania* spp.
Dioscorea spp.	*Solandra* spp.
Duranta erecta (*D. repens*)	*Solanum* spp.
Euphorbia spp.	*Spigelia* spp.
Heliotropium spp.	*Strophanthus* spp.
Hippomane mancinella	*Strychnos* spp.
Hura crepitans	*Thevetia* spp.
Jatropha spp.	

Technical 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. For additional information, contact DPMIAC.

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Appendix A. Vector Ecology Profiles of Malaria Vectors in the Caribbean

Species	Larval Habitats	Feeding Behavior	Resting Behavior	Flight Behavior
An. albimanus	Brackish pools, puddles, marshes and lagoons with emergent vegetation and sunlight.	Feeds throughout the night on man and animals, mostly outdoors.	Rests outdoors.	2 km or more.
An. albitarsus	Sunlit ponds, marshes and large pools with filamentous algae.	Feeds equally on man and animals. Bites indoors and outdoors.	Rests outdoors.	Uncertain.
An. aquasalis	Usually tidal water, including salt marshes and estuaries. Rarely fresh water. Occurs in shade or sunlight.	Feeds on man and domestic animals indoors or outdoors.	Rests outdoors.	Uncertain.
An. bellator	Breeds in leaf axils of bromeliads growing in partial shade.	Anthropophilic but will feed on domestic animals. Nocturnal but feeds in shaded areas, including houses, during the daytime.	Rests indoors if feeding occurs indoors.	Uncertain.
An. homunculus	Uncertain.	Feeds between 1600 and 2000 hours. Will feed readily on man.	Uncertain.	Uncertain.
An. pseudopunctipennis	Sunlit pools and eddies of drying streams, especially with *Spirogyra* algae. Also found in slow moving stream margins in mountains.	Feeds on man and animals, mostly after dark and before dawn. Feeds outdoors more than indoors.	Rests outdoors after feeding.	Uncertain.

Appendix B
Pesticide Resistance in the Caribbean

Vector-borne diseases are an increasing cause of death and suffering in many areas of the world. Efforts to control these diseases have 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 World Health Organization 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. For terrestrial and/or adult stages, the insecticide is either applied topically or insects are exposed to a surface treated with insecticide. For aquatic stages, insecticide is added to water at given 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 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 obtain test kits and additional recommendations for resistance testing contact:

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Tel: (410) 436-3613
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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 in BDUs, bednets, and vector control programs. Studies indicate that resistance appears rapidly in areas where treated bednets are used to control mosquitoes.

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 the world where rice is cultivated.

Innumerable genetic, biologic and operational factors 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.

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Diaz, P.C., J.A. Bisset, T. Gonzalez and M.M. Rodriguez. 1994. [Resistance to organophosphate, carbamate, and pyrethroid insecticides in *Blattella germanica* (Dictyoptera: Blattellidae) in 2 municipalities of the City of Havana.] Rev. Cubana Med. Trop. 46: 130-132.

Diaz, P.C., M.G. Perez, E. Calvo, M.M. Rodriguez and J.A. Bisset. 2000. Insecticide resistance studies on *Blattella germanica* (Dictyoptera: Blattellidae) from Cuba. Ann. N.Y. Acad. Sci. 916: 628-634.

Dieguez-Fernandez, L., J.A. Biset, M.M. Rodriguez, T. Gonzalez, C. Diaz and R. Vazquez. 1999. [Comparative analysis of the resistance to insecticides in strains of *Culex quinquefasciatus*.] Rev. Cubana Med. Trop. 51: 26-32.

Garris, G.I. and N. Barre. 1991. Acaricide susceptibility of *Amblyomma variegatum* (Acari: Ixodidae) from Puerto Rico and Guadeloupe. Exp. Appl. Acarol. 12: 171-179.

Georghiou, G.P., M. Wirth, H. Tram, F. Saume and A.B. Knudsen. 1987. Potential for organophosphate resistance in *Aedes aegypti* (Diptera: Culicidae) in the Caribbean area and neighboring countries. J. Med. Entomol. 24: 290-294.

Hemingway, J., R.G. Boddington and J. Harris. 1989. Mechanisms of insecticide resistance in *Aedes aegypti* (L.) (Diptera: Culicidae) from Puerto Rico. Bull. Ent. Res. 79: 123-130.

Lines, J.D. 1988. Do agricultural insecticides select for insecticide resistance in mosquitoes? A look at the evidence. Parasitol. Today 4: 17-20.

Mekuria, Y., T.A. Gwinn, D.C. Williams and M.A. Tidwell. 1991. Insecticide susceptibility of *Aedes aegypti* from Santo Domingo, Dominican Republic. J. Am. Mosq. Control Assoc. 7: 69-72.

Mekuria, Y., D.C. Williams, M.A. Tidwell and T.A. Santana. 1990. Studies of the susceptibility of *Anopheles albimanus* and *Anopheles vestitipennis* from Dajabon, Dominican Republic, to insecticides. J. Am. Mosq. Control Assoc. 6: 645-650.

Montada, D.D., C.R. Tang, A.O. Navarro and B.R. Gonzalez. 1987. [Susceptibility and/or resistance of larvae of *Anopheles albimanus* Wiedemann, 1821 (Diptera: Culicidae) to organophosphorus insecticides.] Rev. Cubana Med. Trop. 39: 107-115.

Mourya, D.T., J. Hemingway and C.J. Leake. 1993. Changes in enzyme titres with age in four geographical strains of *Aedes aegypti* and their association with insecticide resistance. Med. Vet. Entomol. 71: 11-16.

Navarro, O.A., Tang, C.R., Montada, D.D., C.J. Gomez and V.M. Fresneda. 1986. Detection of DDT resistance in larvae of laboratory-reared *Culex* (*C.*) *quinquefasciatus* Say, 1823 (Diptera: Culicidae). Rev. Cubana Med. Trop. 38: 257-262.

Rawlins, S.C. 1998. Spatial analysis of insecticide resistance in Caribbean populations of *Aedes aegypti*. Rev. Panam. Salud Publica 4: 243-251.

Rawlins, S.C. and S. Lutchman. 1991. Comparative insecticide resistance status of Caribbean populations of the dengue vector, *Aedes aegypti*. West Indian Med. J. 40 (Supplement 1): 27.

Rawlins, S.C., K. Bradshaw and R. Ragoonansingh. 1992. The occurrence of moderate levels of insecticide resistance in some Caribbean strains of *Aedes aegypti*. Resist. Pest Manage. Newsl. 4: 8.

Rawlins, S.C. and R. Ragoonansingh. 1990. Comparative organophosphorus insecticide susceptibility in Caribbean populations of *Aedes aegypti* and *Toxorhynchites moctezuma*. J. Am. Mosq. Control Assoc. 6: 315-317.

Rawlins, S.C. and J.O. Wan. 1995. Resistance in some Caribbean populations of *Aedes aegypti* to several insecticides. J. Am. Mosq. Control Assoc. 11: 59-65.

Rodriguez, M.M., J. Bisset., C. Diaz and A. Soca. 1998. [The selection of a strain of *Culex quinquefasciatus* resistant to lambdacyhalothrin and its spectrum of cross-resistance to other insecticides.] Rev. Cubana Med. Trop. 50: 129-132.

Rodriguez, M.M., J. Bisset, L. Mastrapa and C. Diaz. 1995. [The association of resistance to organophosphate, carbamate, and pyrethroid insecticides with the mechanisms of resistance observed in *Culex quinquefasciatus* strains from Havana City.] Rev. Cubana Med. Trop. 47: 154-160.

Rodriguez, M.M., J. Bisset, J. Rodriguez and C. Diaz. 1997. [Determination of insecticide resistance and its biochemical mechanisms in 2 strains of *Culex quinquefasciatus* from Santiago de Cuba.] Rev. Cubana Med. Trop. 49: 209-214.

Rodriguez, M.M., E. Ortiz, J.A. Bisset, J. Hemingway and E. Saledo. 1993. Changes in malathion and pyrethroid resistance after cypermethrin selection of *Culex quinquefasciatus* field populations of Cuba. Med. Vet. Entomol. 7: 117-121.

Small, G.J., S.H. Karunaratne and J. Hemingway. 1998. Characterization of amplified esterase Estbetal (2) associated with organophosphate resistance in a multi-resistant population of the mosquito *Culex quinquefasciatus* from Cuba. Med. Vet. Entomol. 12: 187-191.

Tang, C.R., D.D. Montada, A.O. Navarro and B.R. Gonzalez. 1987. [Susceptibility and/or resistance to insecticides of adult *Anopheles albimanus* Wiedemann, 1821 (Diptera: Culicidae) used in public health and in agriculture.] Rev. Cubana Med. Trop. 39: 127-131.

Tang, C.R., O.A. Navaro and C.J. Gomez. 1985. [Sensitiveness of a strain of *Aedes aegypti* from Guines, Cuba to temephos and fenthion.] Rev. Cubana Med. Trop. 37: 92-97.

Tang, C.R., O.A. Navaro, D.D. Montada and C.J. Gomez. 1989. [Resistance of *Musca domestica* Linnaeus 1958 (Diptera: Muscidae) to organophosphorus insecticides in a poultry farm, province La Habana.] Rev. Cubana Med. Trop. 41: 34-39.

Villalba, G., C.O. Cordoves and J. Garcia. 1982. Organophosphorus resistance in *Boophilus microplus* Canestrini, 1987. II. Activity of flumethrin on a resistant strain in field tests. Rev. Cubana Ciencias Vet. 13: 7-10.

Villalba, G., F.F. Salabarria, T. Jimenez and P. Valdes. 1982. Organophosphorus resistance in a strain of *Boophilus microplus* Canestrini, 1887. Rev. Cubana Ciencias Vet. 13: 175-182.

Vaughan, A., D.D. Chadee, and R. French-Constant. 1998. Biochemical monitoring of organophosphorus and carbamate insecticide resistance in *Aedes aegypti* mosquitoes from Trinidad. Med. Vet. Entomol. 12: 318-321.

Wirth, M.C. and G.P. Georghiou. 1999. Selection and characterization of temephos resistance in a population of *Aedes aegypti* from Tortola, British Virgin Islands. J. Am. Mosq. Control Assoc. 15: 315-320.

World Health Organization. 1986. Resistance of vectors and reservoirs of disease to pesticides. Tenth report of the WHO expert committee on vector biology and control. WHO Tech. Rep. Ser. 737: 87 pp.

Yebakima, A., M. Raymond, M. Marquine and N. Pasteur. 1995. Resistance to organophosphorus insecticides in *Culex pipiens quinquefasciatus* (Diptera: Culicidae) from Martinique. J. Med. Entomol. 32: 77-82.

Yebakima, A., M.M. Yp-Tcha, P. Reiter, J. Bisset, B. Delay, C. Chevillon and N. Pasteur. 1995. Detoxifying esterases in *Culex pipiens quinquefasciatus* from the Caribbean countries. J. Am. Mosq. Control Assoc. 11: 363-366.

Yan, G.Y., D.D. Chadee and D.W. Severson. 1998. Evidence for genetic hitchhiking effect associated with insecticide resistance in *Aedes aegypti*. Genetics 148: 793-800.

* Only papers published in the 20 years prior to the preparation of this document are included. Many of these articles describe tests on insect populations that were found to be susceptible or contain general discussions about pesticide resistance in the Caribbean. Additional information on insecticide resistance can be found in the annual reports of the Caribbean Epidemiology Centre (CAREC). See website in Appendix H.

Appendix C
Sources of Snake Antivenins

1	Perusahaam Negara Biofarms 9, Jalan Pasteur Bandung, Indonesia
2	Behring Institut, Behringwerke AG, D3550 Marburg (Lahn), Postfach 167, Germany. Telephone: (06421) 39-0. Telefax: (06421) 660064. Telex: 482320-02
3	Institute of Epidemiology and Microbiology, Sofia, Bulgaria
4	Shanghai Vaccine and Serum Institute, 1262 Yang An Road (W), Shanghai, PRC
5	Commonwealth Serum Laboratories, 45 Poplar Road, Parkville, Victoria 3052, Australia Telegram: "SERUMS," Melbourne Telex: AA32789, Telephone: 387-1066
6	Foreign Trade Company, Ltd., Kodandaka, 46 Prague 10, Czech Republic
7	Fitzsimmons Snake Park, Box 1, Snell Park, Durban, South Africa
8	Haffkine Bio-pharmaceutical Corporation, Ltd., Parel, Bombay, India
9	Chiba Serum Institute, 2-6-1 Konodai, Ichikawa, Chiba Prefecture, Japan
10	Institut d'État des Serums et Vaccins Razi, P.O. Box 656, Tehran, Iran
11	Central Research Institute, Kasauli (Simia Hills), (H.P.) India
12	Kitasato Institute, 5-9-1 Shirokane, Minato-ku, Tokyo, Japan
13	The Chemo-Sero Therapeutic Research Institute, Kumamoto, 860 Kyushu, Japan
14	National Institute of Health, Biological Production Division, Islamabad, Pakistan. Telex: 5811-NAIB-PK, Telephone: 820797, 827761
15	Research Institute For Microbial Diseases, Osaka University, 3-1 Yamadoaka, Suite 565, Osaka, Japan, Telephone: (06) 877-5121
16	Institut Pasteur Production, 3 Boulevard Raymond Poincaré, 92430-Mames la Coquette, France. Telephone: (1) 47.41.79.22, Telex: PASTVAC206464F
17	Institut Pasteur d'Algérie Docteur Laveran, Algiers, Algeria
18	Industrial and Pharmaceutical Corporation, Rangoon, Burma
19	Rogoff Medical Research Institute, Beillinson Medical Center, Tel-Aviv, Israel
20	South African Institute for Medical Research, P.O. Box 1036, Johannesburg 2000, Republic of South Africa. Telegraph: "BACTERIA", Telephone: 724-1781
21	Instituto Sieroterapica e Vaccinogeno Toscano "Sclavo", Via Fiorentina 1, 53100 Siena, Italy.
22	National Institute of Preventive Medicine, 161 Kun-Yang St., Nan-Kang, Taipei, Taiwan
23	Takeda Chemical Industries, Ltd., Osaka, Japan
24	Research Institute of Vaccine and Serum, Ministry of Public Health U.I. Kafanova, 93 Tashkent, USSR
25	Red Cross Society, Queen Saovabha Memorial Institute, Rama 4 Road, Bangkok, Thailand 26
26	Twyford Pharmaceutical Services Deutschland, GmbH, Postfach 2108 05, D-6700 Ludwigshafen am Rhein, Germany
27	Institute of Immunology, Rockefellerova 2, Zagreb, Yugoslavia

Appendix D
Selected List of Taxonomic Papers and Identification Keys*

General

Hogue, C.L. 1993. Insects of Latin America. University of California Press, Berkeley.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Bahama Islands). Dept. Ent., Cornell Univ. No. 17. 16 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Cuba). Dept. Ent., Cornell Univ. No. 18. 50 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Dominican Republic). Dept. Ent., Cornell Univ. No. 19. 29 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Haiti). Dept. Ent., Cornell Univ. No. 20. 33 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Jamaica). Dept. Ent., Cornell Univ. No. 21. 52 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Puerto Rico). Dept. Ent., Cornell Univ. No. 22. 52 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Greater (Virgin Islands). Dept. Ent., Cornell Univ. No. 23. 26 pp.

Travis, B.V. 1955. List of arthropods of medical importance: Antilles, Lesser. Dept. Ent., Cornell Univ. No. 24. 53 pp.

Ceratopogonidae

Aitken, T.H. 1975. A review of the bloodsucking midges of Trinidad and Tobago, West Indies (Diptera: Ceratopogonidae). J. Med. Entomol. 44: 101-144.

Atchley, W.R., W.W. Wirth and C.T. Gaskins. 1981. A bibliography and keyword index of the biting midges (Diptera: Ceratopogonidae). USDA Sci. Educ. Admin. Bibliogr. Lit. Agric. No. 13: 1-544.

Davies, J.E. and M.E. Giglioni. 1979. The Ceratopogonidae (Diptera) of Grand Cayman, West Indies. Mosq. News 39: 586-594.*

Chiggers

Brennan, J.M. 1953. A note on the chiggers of Jamaica (Acarina: Trombiculidae). J. Parasitol. 39: 1-4.

Cimicidae

Ryckman, R.E., D.G. Bentley and E.F. Archbold. 1981. The Cimicidae of the Americas and Oceanic Islands, a checklist and bibliography. Bull. Soc. Vector Ecol. 6: 93-142.

Culicidae

Arnell, J.H. 1973. Mosquito studies (Diptera, Culicidae). XXXII. A revision of the genus *Haemagogus*. Amer. Entomol. Inst. Contrib. 10: 1-174.

Breeland, S.G. 1980. A bibliography to the literature of *Anopheles albimanus* (Diptera: Culicidae). Mosq. Syst. 12: 50-150.

Cook, D.R. 1954. Pictorial keys to the mosquitoes of medical importance. VIII. West Indies. Mosq. News 14: 152-153.*

Fize, J.M. 1976. [The mosquitoes of Martinique.] 1976. Cash. Orstom, Sér. Entomol. Med. Parasitol.14: 15-29.*

Gaffigan, T.V. and R.A. Ward. 1985. Index to the second supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 17: 52-63.

Gonzales, B.R. and R.J. Rodriguez. 1997. [Updated list of the mosquitoes of Cuba.] Cocuyo 6: 17-18.

Knight, K.L. 1978. Supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Thomas Say Found., Entomol. Soc. Am., Vol. 6, 107 pp.

Knight, K.L. and A. Stone. 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). 2nd ed. Thomas Say Found., Entomol. Soc. Am., Vol. 6, 611 pp.

Mattingly, P.F. 1971. Illustrated key to the genera of mosquitoes. Amer. Entomol. Inst. Contrib. 7:1-84.*

Pecor, J.E., V.L. Mallampalli, R.E. Harbach and E.L. Peyton. 1992. Catalog and illustrated review of the subgenus *Melanoconion* of *Culex* (Diptera: Culicidae). Amer. Entomol. Inst. Contrib. 27: 1-228.*

Senior White, R.A. 1950. The distribution of the culicid tribe anophelinae around the Caribbean Sea. Carib. Med. J. 12: 67-71.

Ward, R.A. 1984. Second supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 16: 227-270.

Ward, R.A. 1992. Third supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 24: 177-230.

Mammalia

Nowak, R.M. (ed.) 1999. Walker's mammals of the world. 6th ed., John Hopkins University Press, Baltimore.

Wilson, D.E. and D.M. Reeder. 1993. Mammal species of the world: a taxonomic and geographic reference. 2nd ed., Smithsonian Institution Press, Washington, DC.

Psychodidae

Young, D.G. and M.A. Duncan. 1994. Guide to the identification and geographic distribution of *Lutzomyia* sand flies in Mexico, the West Indies, Central and South America (Diptera: Psychodidae). Mem. Am. Ent. Inst., No. 54: 1-881.*

Reptiles

Campbell, J.A. and W.W. Lamar. 1989. The venomous reptiles of Latin America. Cornell University Press, Ithaca.

Harding, K.A. and K.R.G. Welch. 1980. Venomous snakes of the world: a checklist. Pergamon Press, Oxford.

McDiarmid, R., J. Campbell and T. Toure. 1999. Snake species of the world. A taxonomic and geographic reference. Volume I. The Herpetologist's League, Washington, DC.

Poisonous snakes of the world, a manual for use by U.S. amphibious forces. 1966. NAVMED P-5099, BUMED, Department of the Navy, U.S. Gov. Print. Off.*

Scorpions

Couzjin, H.W.C. 1981. Revision of the genus *Heterometrus* Hemprich & Ehrenberg (Scorpionidae, Arachnidea). Zool. Verhandelingen No. 184: 1196 pp.*

El Hennawy, H.K. 1990. Key to scorpion families (Arachnida: Scorpionida). Serket 2: 14-19.*

Franke, O.F. 1978. Systematic revision of the diplocentrid scorpions (Diplocentridae) from the circum-Caribbean lands. Texas Tech Press, Lubbock.

Keegan, H.L. 1980. Scorpions of medical importance. Univ. Press Miss., Jackson.

Kjellesvig-Waering, E. 1968. The scorpions of Trinidad and Tobago. Caribbean J. Sci. 6: 123-135.*

Santiago-Blay, J.A. 1987. The scorpions of Dominica (West Indies). J. Entomol. Sci. 22: 311-316.

Sissom, W.D. 1990. Systematics, biogeography, and paleontology. pp. 64-136 *In:* The biology of scorpions, G.A. Polis (ed.). Stanford Univ. Press.*

Stahnke, H.L. 1972. A key to the genera of Buthidae (Scopionida). Ent. News 83: 121-133.*

Simuliidae

Kim, K.C. and R.W. Merritt. 1987. Black flies - ecology, population management, and annotated world list. Penn. State Univ., University Park.

Stone, A. 1969. The black flies of Dominica (Diptera: Simuliidae). Proc. Entomol. Soc. Wash. 71: 312-318.

Siphonaptera

Adams, N.E. and R.E. Lewis. 1985. An annotated catalogue of primary types of Siphonaptera in the National Museum of Natural History, Smithsonian Institution. Smithson. Contri. Zool. No. 56: 1-86.

Lewis, R.E. 1990. The Ceratophyllidae: currently accepted valid taxa (Insecta: Siphonaptera). Theses Zoologicae, volume 13. R. Fricke (ed.). Koeltz Scientific Books. Koenigstein, Germany.

Lewis, R.E. and J.H. Lewis. 1989. Catalogue of invalid genus-group and species-group names in the Siphonaptera (Insecta). Theses Zoologicae, Volume 11. R. Fricke (ed.). Koeltz Scientific Books. Koenigstein, Germany.

Traub, R., M. Rothschild and J.F. Haddow. 1983. The Rothschild collection of fleas. The Ceratophyllidae: key to the genera and host relationships. With notes on their evolution, zoogeography and medical importance. Privately published by M. Rothschild and R. Traub. Distributed by Academic Press.

Spiders

Gertsch, W.J. and F. Ennik. 1983. The spider genus *Loxosceles* in North America, Central America and the West Indies (Araneae, Loxoscelidae). Bull. Amer. Mus. Nat. Hist. 175: 264-360.

Tabanidae

Fairchild, G.B. 1966. The Tabanid fauna of the West Indies. Proc. First Int. Congr. Parasitol. Roma: 993-995.

Fairchild, G.B. 1980. Tabanidae (Diptera) from the Dominican Republic. Fla. Entomol. 63: 166-188.*

Ticks (Ixodidae, Argasidae)

Balashov, Yu. S. 1972. Bloodsucking ticks (Ixodoidea) - vectors of diseases of man and animals. Misc. Publ. Entomol. Soc. Amer. 8: 1-376.

Triatominae

Ryckman, R.E. 1984. The Triatominae of North and Central America and the West Indies: a checklist with synonymy (Hemiptera: Reduviidae: Triatominae). Bull. Soc. Vector Ecol. 9:71-83.

Ryckman, R.E. 1986. Names of the Triatominae of North America and Central America and the West Indies: their histories, derivations and etymology (Hemiptera: Reduviidae: Triatominae). Bull. Soc. Vector Ecol. 11: 209-220.

*Papers marked with an asterisk include a taxonomic key for identification of species. References without keys for identification usually contain a checklist of species known from a given geographic area or a list of species collected during extensive surveys of an area.

Appendix E
Personal Protective Measures

Personal protective measures are the first line of defense against arthropod-borne disease and, in some cases, may be the only protection for deployed military personnel. 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 and other blood-sucking insects. Therefore, the uniform should be worn to cover as much skin as possible if weather and physical activity permit. When personnel are operating in tick-infested areas, they should tuck their pant legs into their boots to prevent access to the skin by ticks, chiggers, and other crawling arthropods. They should also check themselves frequently for ticks and immediately remove any that are found. If a tick has attached, seek assistance from medical authorities for proper removal or follow these guidelines from TG 36, Section IX A.

1. **Grasp the tick's mouthparts** where they enter the skin, using pointed tweezers.

2. **Pull out** slowly and steadily with gentle force.

    a. Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter.

    b. **Be patient** – The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time consuming.

    c. Many hard ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh and adds to the difficulty of removal.

    d. It is important to continue to pull steadily until the tick can be eased out of the skin.

    e. **Do not** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, don't panic. Embedded mouthparts are comparable to having a splinter in your skin. However, to prevent secondary infection, it is best to remove them. Seek medical assistance if necessary.

    f. **Do not** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound.

    g. **Do not** apply substances like petroleum jelly, fingernail polish remover, repellent pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective or, worse, may agitate the tick and cause it to salivate or regurgitate infective fluid into the wound site.

h. If tweezers are not available, grasp the tick's mouthparts between your fingernails, and remove the tick carefully by hand. Be sure to wash your hands -- especially under your fingernails -- to prevent possible contamination by infective material from the tick.

3. Following removal of the tick, **wash the wound** (and your hands) with soap and water and **apply an antiseptic**.

4. **Save the tick** in a jar, vial, small plastic bag, or other container for identification, should you later develop disease symptoms. Preserve the tick by either adding some alcohol to the jar or by keeping it in a freezer. Storing a tick in water will not preserve it. Identification of the tick will help the physician's diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.

5. **Discard** the tick after one month; all known tick-borne diseases will generally display symptoms within this time period.

Newly developed repellents provide military personnel with unprecedented levels of protection. An aerosol formulation of permethrin (NSN 6840-01-278-1336) can be applied to the uniform according to label directions, but not to the skin. This will impart both repellent and insecticidal properties to the uniform material that will be retained through numerous washings. An extended formulation lotion of N,N-diethyl-m-toluamide (DEET) (NSN 6840-01-284-3982) has been developed to replace the 2 oz. bottles of 75% deet in alcohol. This lotion contains 33% active ingredient. It is less irritating to the skin, has less odor and is generally more acceptable to the user. A properly worn Battle Dress Uniform (BDU) impregnated with permethrin, combined with use of extended duration DEET on exposed skin, has been demonstrated to provide nearly 100% protection against a variety of blood-sucking arthropods. This dual strategy is termed the **DoD ARTHROPOD REPELLENT SYSTEM**. In addition, permethrin may be applied to bednets, tents, and other field items as appropriate. Complete details regarding these and other personal protective measures are provided in TG 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance (2001).

F. Bioscience and State Department Contacts in the Caribbean.

1. **Regional Contacts**.

World Health Organization (WHO) Phone: +00-41-22-791-2111
Headquarters Office in Geneva (HQ) FAX: +00-41-22-791-3111
Avenue Appia 20
1211 Geneva 27, Switzerland Website: < http://www.who.int/home/hq.html >

Regional Office for the Americas / Pan Phone: +1 202-974-3000
American Health Organization (PAHO) FAX: +1 202-974-3663
525 23rd Street, NW
Washington, DC 20037 E-mail: < postmaster@paho.org >

Centers for Disease Control and Prevention (CDC)
Division of Quarantine Phone: (404) 639-3311
National Center for Infectious Diseases e-mail: < netinfo@cdc.gov >
1600 Clifton Road, NE
Atlanta, GA 30333 Website: < http://www.cdc.gov/travel/index.htm >
U.S.A.
Travelers' Health Hotline: 877-FYI-TRIP (= 394-8747); FAX: 888-232-3299

2. **Anguilla**.

No direct U.S. diplomatic representation; an overseas territory of the UK.

3. **Antigua and Barbuda**.

Contact: U.S. Ambassador, Bridgetown, Barbados (accredited to Antigua and Barbuda).

4. **Aruba**. (part of the Kingdom of the Netherlands)

Consul General Phone: 599-9-461-3066
J.B. Gorsiraweg #1 FAX: 599-9-461-6489
Curaçao, Netherlands Antilles

5. **The Bahamas**.

Ambassador Phone: 1-242-322-1181
American Embassy FAX: 1-242-356-0222
Queen Street, Nassau local address: P.O. Box N-8197
U.S. address: American Embassy Nassau, P.O. Box 599009, Miami, FL 33159-9009

6. **Barbados**.

Ambassador (or Chargé d'Affairs) Phone: 1-246-436-4950
Canadian Imperial Bank of Commerce Bldg.

Broad Street, Bridgetown FAX: 1-246-429-5246

Mailing address: P.O. Box 302, Bridgetown, Barbados
or (from the U.S.) FPO AA 34055

7. **British Virgin Islands**.
No direct U.S. diplomatic representation; an overseas territory of the UK.

8. **Cayman Islands**.
No direct U.S. diplomatic representation; an overseas territory of the UK.

9. **Cuba**.
Note: The U.S. has an Interests Section in the Swiss Embassy, headed by:

Principal Officer	Phone: 33-3551 through 3559 and
USINT, Swiss Embassy	33-3543 through 3547
Calzada, between L and M Streets	(Operator assistance required)
Vedado Seccion, Havana	FAX: 33-3700

10. **Dominica**.
Contact: U.S. Ambassador, Bridgetown, Barbados (accredited to Dominica).

11. **Dominican Republic**.
Ambassador ` Phone: 1-809-221-2171
U.S. Embassy FAX: 1-809-686-7437
Corner of Calle Cesar Nicolas and Calle Leopoldo Navarro
Santo Domingo, Dominican Republic
or (from the U.S.): Unit 5500, APO AA 34041-5500

12. **Grenada**.
Contact: U.S. Ambassador, Bridgetown, Barbados (accredited to Grenada).

13. **Guadeloupe**.
No direct U.S. diplomatic relations; an overseas Department of France.

14. **Haiti**.

Ambassador (or Chargé d'Affairs)	Phone: 509- 22-0354, 22-0368,
5 Harry Truman Boulevard	22-0200, or 22-0612
Port-au-Prince, Haiti	FAX: 509-23-1641

Local address: P.O. Box 1761, Port-au-Prince, Haiti

15. **Jamaica**.

Ambassador | Phone: 1-809-929-4850 through –4859
U.S. Embassy
Jamaica Mutual Life Center | FAX: 1-809-926-6743
2 Oxford Road, 3rd Floor
Kingston, Jamaica | Send mail to street address (at left).

16. **Martinique**.

No direct U.S. diplomatic relations: an overseas Department of France.

17. **Montserrat**.

No direct U.S. diplomatic representation; an overseas territory of the UK.

18. **Navassa Island**. This is an unincorporated territory of the U.S., administered from Washington, DC by the U.S. Fish and Wildlife Service.

19. **Netherlands Antilles**. (These are part of the Kingdom of the Netherlands)

Consul General | Phone: 599-9-461-3066
J.B. Gorsiraweg # **1** | FAX: 599-9-461-6489
Curaçao | local address: P.O. Box 158, Willemstad, Curaçao

20. **Puerto Rico**. (A commonwealth of the U.S.; no diplomatic relations required.)

21. **Saint Kitts and Nevis**. (Part of the British Commonwealth.)

Contact: U.S. Ambassador, Bridgetown, Barbados (accredited to Saint Kitts and Nevis).

22. **Saint Lucia**. (Part of the British Commonwealth.)

Contact: U.S. Ambassador, Bridgetown, Barbados (accredited to Saint Lucia.).

23. **Saint Vincent and the Grenadines**.

Contact: U.S. Ambassador, Bridgetown, Barbados
(accredited to Saint Vincent and the Grenadines.)

24. **Trinidad and Tobago**.

Ambassador | Phone: 1-80-9-622-6372 through –6376,
U.S. Embassy | and 622-6176
15 Queen's Park West | FAX: 1-809-628-5462
Port-of-Spain, Trinidad and Tobago
Local mailing address: P.O. Box 752, Port-of-Spain, Trinidad and Tobago

25. **Turks and Caicos Islands**.
No direct U.S. Diplomatic representation; an overseas territory of the UK.

26. **Virgin Islands**. (A territory of the U.S.; no diplomatic relations required.)

Appendix G: Glossary

acaricide - a substance developed to kill ticks and mites.
adulticide - insecticides used to kill the adult stages of an insect.
anaphylaxis - an unusual and severe allergic reaction of an organism to a foreign protein or other substances.
anthropophilic - the preference of insects and other arthropods to suck blood from humans rather than from animals.
autochthonous - transmission of a disease in the place where the disease occurred.
autogenous - not requiring a bloodmeal to produce eggs.
bionomics - the ecology of an organism.
biotope - a habitat characterized by environmental conditions and its community of animals and plants.
campestral - relating to fields or open country.
carrier - a person or animal that harbors infectious organisms but is free of clinical disease generally synonymous with reservoir.
case fatality rate - the percentage of persons diagnosed as having a specific disease who die as a result of that illness within a given period.
cephalothorax - a body region consisting of head and thoracic segments.
cercaria (pl. cercariae) - free-living stage in the life cycle of *Schistosoma* that emerges from snails and infects vertebrate hosts.
chelicerae - a pair of appendages used as mouthparts in arachnids such as scorpions, spiders, and ticks.
chemoprophylaxis - the administration of a chemical to prevent the development of an infection or the progression of an infection to active disease.
ciguatera poisoning - a syndrome of gastrointestinal and neurological symptoms that occurs shortly after eating coral reef fish (e.g., barracudas, groupers, sea basses, snappers, parrotfishes and many other species) that have accumulated the toxin from the dinoflagellate *Gambierdiscus toxicus* and possibly other coral reef algae.
commensal - living in close association with another organism.
crepuscular - the twilight periods of light at dusk and dawn.
delayed contact sensitivity - reaction of skin or other tissue that takes 24 to 48 hours to develop and involves cell mediated immunity.

diapause - a period of arrested development and reduced metabolic rate, during which growth and metamorphosis cease.

diurnal - activities occurring during the daytime.

ectoparasite - a parasite that lives on the exterior of its host.

endemic - the constant presence of a disease or infection within a given geographic area.

endophagic - an arthropod that prefers to feed indoors.

endophilic - the tendency of arthropods to enter human structures.

enzootic - a disease that primarily infects animals and is present in an animal community at all times.

epidemic - the occurrence of cases of an illness (or an outbreak) that is clearly in excess of normal expectancy.

epizootic - an outbreak of a disease within an animal population.

eutrophic - rich in nutrients; usually applied to aquatic ecosystems.

exophagic - the tendency of an arthropod to feed outdoors.

exophilic - the tendency of blood-sucking arthropods to feed and rest outdoors.

facultative - not obligatory; characterized by the ability to adjust to circumstances.

family - a group of related genera.

focus (pl. foci) - a specific localized area.

genus (pl. genera) - a group of closely related species.

gonotrophic cycle - the time between feeding, egg development and oviposition.

immediate contact sensitivity - reaction of skin or other tissue within minutes after the interaction of a chemical antigen with antibody.

inapparent infection - the presence of infection in a host without clinical symptoms.

incidence - the number of new cases of a specific disease occurring during a certain period of time.

incubation period - the time interval between initial contact with an infectious agent and the first appearance of symptoms associated with the infection.

indigenous - living or occurring naturally in a particular environment or area.

infection rate - the proportion (expressed as a percent) of a vector or host population that is infected.

infective - an organism that can transmit an infectious agent to another individual.

instar - an insect between successive molts.

larva (pl. larvae) - the immature stage, between the egg and pupa of an insect, or the six-legged immature stage of a tick.

larvicide - insecticides used to kill larvae or immature stages of an insect.

larviparous - insects that deposit larvae rather than eggs on a host, food source, or other substrate.

maggot - legless larva of flies (Diptera).

mechanical transmission - the vector transmits the pathogen on contaminated mouthparts, legs, or other body parts, or by passage through the digestive tract without change.

miracidium (pl. miracidia) - ciliated, first larval stage in the life cycle of *Schistosoma* that penetrates and infects a snail, undergoing further development in the snail.
molluscicide - a chemical substance used for the destruction of snails and other molluscs.
myiasis - the invasion of human tissues by fly larvae.
night soil - human excrement used as fertilizer.
nosocomial - originating in a hospital or medical treatment facility.
nulliparous - a female arthropod that has not laid eggs.
nymph - an immature stage of an insect that does not have a pupal stage or an eight-legged immature tick or mite.
obligate - necessary or compulsory; characterized by the ability to survive only in a particular environment.
pandemic - a widespread epidemic disease distributed throughout a region or continent.
parous - a female arthropod that has laid eggs.
pedipalps - the second pair of appendages of an arachnid.
periurban - relating to an area immediately surrounding a city or town.
prevalence - the total number of cases of a disease in existence at a certain time in a designated area.
photoallergy - an increased reactivity of the skin to ultraviolet and/or visible radiation on an immunological basis.
phototoxicity - an increased reactivity of the skin to ultraviolet and/or visible radiation on a nonimmunological basis.
pupa (pl. pupae) - a nonfeeding and usually inactive stage between the larval and adult stage.
quest (questing) - the behavior of ticks waiting in search of a passing host.
refractory - a host or vector that will not permit development or transmission of a pathogen.
reservoir - any animal, plant or substance in which an infectious agent survives and multiplies.
rodenticide - a chemical substance used to kill rodents, generally through ingestion.
ruminants - relating to a group of even-toed mammals such as sheep, goats and camels that chew the cud and have a complex stomach.
sequelae - any after effects of disease.
species complex - a group of closely related species, the taxonomic relationships of which are sometimes unclear, making individual species identification difficult.
sylvatic - related to a woodland or jungle habitat.
synanthropic - animals that live in close association with man.
synergist - a chemical that may have little or no toxicity in itself but, when combined with a pesticide, greatly increases the pesticide's effectiveness.
transovarial transmission - passage of a pathogen through the ovary to the next generation .
transstadial transmission - passage of a pathogen from one stage of development to another after molting.
ultra low volume (ULV) - the mechanical dispersal of concentrated insecticides in aerosols of extremely small droplets that drift with air currents.
urticaria - a reaction of the skin marked by the appearance of smooth, slightly elevated patches

(wheals) that are redder or paler than the surrounding skin and often associated with severe itching.

vector - an organism that transmits a pathogen from one host to another.

vector competence - the relative capability of a vector to permit the development, multiplication and transmission of a pathogen.

vesicant - a blistering agent.

viremia - a virus that is present in the blood.

virulence - the degree of pathogenicity of an infectious agent.

xerophilic - tolerant of dry environments.

zoonosis - an infectious disease of animals transmissible under natural conditions from nonhumans to humans.

zoophilic - the preference of arthropods to feed on animals other than humans.

Appendix H
Internet Websites on Medical Entomology and Vector-borne Diseases

1. The Armed Forces Pest Management Board's website provides information about the Board as well as Army, Navy and Air Force entomology programs. Users can download Board publications, including Technical Information Memorandums, Disease Vector Ecology Profiles, and Technical Information Bulletins, and search the Defense Pest Management Information Analysis Center's literature database.
   <http://www.afpmb.org/>

2. Emerging diseases website, with current information on disease outbreaks.
   <http://www.fas.org/promed>

3. Iowa State University's comprehensive site on medical entomology, with excellent information and links to over 20 additional sites.
   <http://www.ent.iastate.edu/>

4. World Health Organization disease outbreak information – emerging and communicable disease information from the WHO and its databases. The tropical medicine databases are the most useful for vector-borne diseases. Access can also be obtained to the Weekly Epidemiological Record.
   <http://www.who.int/emc/index.html>

5. The Walter Reed Biosystematic Unit's online information regarding taxonomic keys, diseases transmitted by mosquitoes, and mosquito identification modules.
   <http://wrbu.si.edu/>

6. Centers for Disease Control and Prevention – information on the CDC's travel alerts, including access to country health profiles, vaccine recommendations, State Department entry requirements, and publications.
   <http://www.cdc.gov/travel/>

7. The National Library of Medicine's biomedical databases, especially Medline. Provides complete references and abstracts to more than 9 million journal articles from biomedical publications.
   <http://www.nlm.nih.gov/>

8. The Malaria Foundation International's site for general resources on malaria available through the Worldwide Web. Includes references, malaria advisories, and lists of other malaria websites.
   <http://www.malaria.org>

9. The WHO site for information on vector-borne diseases, including disease distribution, information on disease outbreaks, travel alerts, WHO research programs, and progress on control.

<http://www.who.ch/>

10. The CDC's site for information on diseases, as published in the Morbidity and Mortality Weekly Report and other publications, including Emerging Infectious Diseases. Includes case definition and disease outbreak information. Provides access to other websites. <http://www.cdc.gov/epo/mmwr/other/case_def/enceph.html>

11. Information from the University of Florida's website on mosquitoes and other biting flies. <http://hammock.ifas.ufl.edu/text/ig/8804.html>

12. Information on ticks and other ectoparasites from the University of Rhode Island's Tick Research Laboratory. Includes information on tick-borne diseases, tick images, and links to related sites. <http://www.riaes.org/resources/ticklab/>

13. Information on plague available from the CDC's Morbidity and Mortality Weekly Report. <http://www.cdc.gov/epo/mmwr/other/case_def/plague.html>

14. A list of websites and servers pertaining to entomology from Colorado State University. Over 30 websites are listed. <http://www.colostate.edu/Depts/Entomology/ent.html>

15. Lyme Disease Network – information on Lyme disease, including research abstracts, treatments for Lyme disease, newsletter, conferences, and professional resources. <http://www.lymenet.org>

16. The USDA plant database – includes the integrated taxonomic information system. <http://plants.usda.gov/ >

1. University of Sydney, Medical Entomology – contains information on mosquito keys, fact sheets, and photos of mosquitoes. <http://medent.usyd.edu.au>

2. American Society of Tropical Medicine and Hygiene – information on the ASTMH's programs, conferences, newsletters, publications, and resources. <http://www.astmh.org >

3. The American Mosquito Control Association's site containing information on mosquito biology, AMCA programs, conferences, newsletters, publications, and resources. <http://www.mosquito.org>

4. Reuters' search engine on health news pertaining to health issues around the world. <http://www.reutershealth.com/>

5. The ORSTOM home page includes information about the organization's medical research program in Asia, Africa, and Latin America. Bulletins and publications on its research are offered. (primarily in French)
<http://www.orstom.fr/>

6. Emory University's website allows access to the University's extensive database of medical and scientific literature, including infectious diseases.
<http://www.medweb.emory.edu/medweb/>

7. The Entomological Society of America offers information on its overall services, including conferences, journals, references, membership, and literature available for ordering.
<http://www.entsoc.org>

8. Travel Health Online contains country profiles with health precautions and disease risk summaries, general travel health advice, contacts for providers of pre-travel health services, and access to U.S. State Department publications.
<http://www.tripprep.com>

9. Caribbean Epidemiology Center. Contains current epidemiological information on public health, including arthropod-borne diseases, in the Caribbean region as well as a list of publications and related websites.
<http://www.carec.org>

10. Barbados Leptospira Laboratory. Describes the mission of the laboratory, established in 1979, and provides epidemiological information on leptospirosis in the Caribbean and links to other leptospirosis websites.
<http://www.users.sunbeach.net/users/levett/lepto.htm>

11. Major Scott Stockwell, U.S. Army, has compiled a website on scorpion stings, phylogeny, classification and identification, as well as links to other scorpion websites.
<http://wrbu.si.edu/www/stockwell/classification/classification.html>

12. The Tulane University School of Public Health. Contains information on Tulane academic and research programs, including research on vector biology.
<http://www.tropmed.tulane.edu/>

13. BIREME is a PAHO specialized center established in Brazil in 1967 that promotes technical cooperation and exchange of scientific and public health information among Latin American and Caribbean countries. It has a searchable scientific literature database.
<http://www.bireme.br>

14. London School of Hygiene and Tropical Medicine provides information on its programs of training, study and research in tropical medicine, library services, and access to annual reports. <http.www.lshtm.ac.uk>

15. Liverpool School of Tropical Medicine provides information on its programs of study and research, including parasite and vector ecology, as well as recent publications of each department.
<http://www.liv.ac.uk/lstm/lstm.html>

32. The University of the West Indies, Mona Campus, Kingston, Jamaica. Offers a medical library with some online databases and journals including Medcarib which contains information on all aspects of health and medicine relating to the English speaking Caribbean and Suriname.
<http://www.uwimona.edu.jm/>

Appendix I. Metric Conversion Table.

Metric System

LINEAR MEASURE

10 millimeters	=	1 centimeter
10 centimeters	=	1 decimeter
10 decimeters	=	1 meter
10 meters	=	1 decameter
10 decameters	=	1 hectometer
10 hectometers	=	1 kilometer

AREA MEASURE

100 sq. millimeters	=	1 sq. centimeter
10,000 sq. centimeters	=	1 sq. meter
1,000,000 sq. millimeters	=	1 sq. meter
100 sq. meters	=	1 sq. are
100 acres	=	1 hectare
100 hectares	=	1 sq. kilometer
1,000,000 sq. meters	=	1 sq. kilometer

VOLUME MEASURE

1 liter	=	0.001 cubic meters
10 milliliters	=	1 centiliter
10 centiliters	=	1 deciliter
10 decaliters	=	1 liter
10 liters	=	1 decaliters
10 decaliters	=	1 hectoliter
10 hectoliters	=	1 kiloliter

WEIGHT

10 milligrams	=	1 centigram
10 centigrams	=	1 decigram
10 decigrams	=	1 gram
10 grams	=	1 decagram
10 decagrams	=	1 hectogram
10 hectograms	=	1 kilogram
1,000 kilograms	=	1 metric ton

U.S. Customary System

LINEAR MEASURE

12 inches	=	1 foot
3 feet	=	1 yard
5 ½ yards	=	1 rod
40 rods	=	1 furlong
8 furlongs	=	1 mile
3 land miles	=	1 league

AREA MEASURE

144 sq. inches	=	1 sq. foot
9 sq. feet	=	1 sq. yard
30 ¼ sq. yards	=	1 sq. rod
160 sq. rods	=	1 acre
640 acres	=	1 sq. mile
1 sq. mile	=	1 section
36 sections	=	1 township

LIQUID MEASURE

4 gills (2 cups)	=	1 pint
2 pints	=	1 quart
4 quarts	=	1 gallon

DRY MEASURE

2 pints	=	1 pint
8 quarts	=	1 peck
4 pecks	=	1 bushel

WEIGHT

27 11/32 grains	=	1 dram
16 drams	=	1 ounce
16 ounces	=	1 pound
100 pounds	=	1 hundredweight
20 hundredweight	=	1 ton

Kitchen Measurements

3 tsp.	=	1 tbsp.	5 1/3 tbsp.	=	1/3 cup	2 cups	=	1 pint	2 pints	=	1 quart
4 tbsp.	=	¼ cup	16 tbsp.	=	1 cup	4 cups	=	1 quart	4 quarts	=	1 gallon

Temperature

Celsius = $\frac{5}{9}(F-32)$ Fahrenheit = $\frac{9C}{5} + 32$

Conversion Table

To Convert	Into	Multiply by	To Convert	Into	Multiply by	To Convert	Into	Multiply by
Centimeters	Inches	.394	Liters	Cups	4.226	Miles	Feet	5,280
	Feet	.0328		Pints	2.113		Yards	1,760
	Meters	.01		Gallons	.264		Kilometers	1.609
	Millimeters	10		Milliliters	1000	Pints	Liters	.473
				Quarts	1.057		Quarts	.5
Meters	Centimeters	100	Grams	Ounces	.035		Gallons	.125
	Feet	3.281		Pounds	.002	Quarts	Pints	2
	Inches	39.37		Kilograms	.001		Liters	.946
	Kilometers	.001	Kilogram	Grams	1,000		Gallons	.25
	Miles	.0006214		Ounces	35.274	Gallons	Pints	8
	Millimeters	1000		Pounds	2.205		Liters	3.785
	Yards	1.093	Inches	Centimeters	2.54		Quart	4
				Feet	.0833	Ounces	Grams	28.35
Kilometers	Feet	3281		Meters	.0264		Pounds	.0625
	Meters	1000		Yards	.0278		Kilograms	.028
	Miles	.621	Yards	Inches	36	Pounds	Grams	453.59
	Yards	1093		Feet	3		Ounces	16
				Meters	.914		Kilograms	.454
				Miles	.0005682			