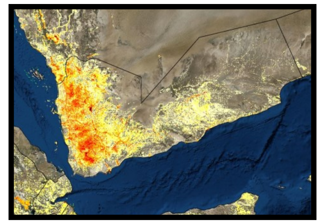
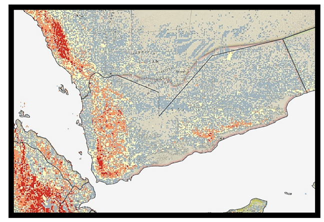
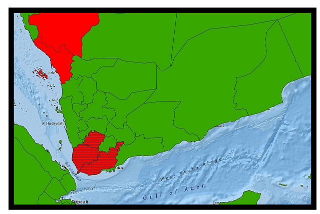
# Disease Vector Hazard Report:

# Yemen





Notes on the arthropod-borne disease threats, vector species ecology profiles and recommendations for surveillance and control.

U.S. Department of Defense Armed Forces Pest Management Board

WRAIR Walter Reed Army Institute of Research Soldier Health • World Health

WRBU Walter Reed Biosystematics Unit Know the vector, know the threat

2018

# Preface

This product was co-produced by the Armed Forces Pest Management Board (AFPMB) and the Walter Reed Army Institute of Research, Walter Reed Biosystematics Unit (WRAIR-WRBU)

This document provides summarized information on the vectors and vector-borne diseases reported from Yemen as of January, 2018. Information related to the identification, distribution, medical importance, control and surveillance of vector species are included. For updated information on the current hazards known from Yemen, please use the near-real time hazard assessment links on page 3. Each page of this document is also hyperlinked via the table of contents to allow easy navigation and access to information most relevant to the reader. This report contains background information including **a** country overview, climate summary and host demographics**.** View the Vector Hazard Report Quick Guide pages for real-time threat assessment resources, quick navigation to vector-borne disease threats in Yemen and resources for vector identification and monitoring insecticide resistance for updated information about current outbreaks and regional climate. Detailed bionomics data for each vector species is available on the vector species ecology profile pages for mosquitoes and ticks.

The target audience for this document are commanders, medical planners, preventive medicine personnel, and particularly medical entomologists.

For each vector-borne disease threat included in the report the following information is provided:

- **Disease Background**
- **Military Impact and Historical Perspective**
- **Transmission Cycle**
- **Additional Resources**

For each vector species threat included in this report, the following information is provided:

- **Current Taxonomy**
- **Bionomics**
- **Medical Importance**
- **Identification Tools**
- **Surveillance and Control Strategies**
- **Additional Resources**

# Vector Hazard Report Quick Guide: Yemen

| Real-Time Threat Assessment Resources<br><br>Visit these websites for regularly updated information about current vector-borne disease threats and regional climate. |
| --- |
| U.S. Dept. of State Travel Alerts |
| Health.mil Reports |
| CDC Current Outbreaks List |
| WHO Outbreak News |
| HealthMap Outbreaks |
| VectorMap Current Climate |
| AccuWeather Current Radar |

| Additional Resources |
| --- |
| WHO Country Profile: Yemen |
| CDC Travelers Guide: Yemen |
| Global Mosquito Vectors of Arboviruses of the World |

| Militarily Important Vector-Borne Diseases with Short Incubation Periods (<15 days) | Vector |
| --- | --- |
| Malaria | Mosquito |
| Dengue Fever/ Chikungunya | Mosquito |
| West Nile Fever | Mosquito |
| Rift Valley Fever | Mosquito |
| Sindbis Virus | Mosquito |
| Sand Fly Fever | Sand Fly |
| Relapsing Fever (Louse-borne) | Louse |
| Relapsing Fever (Tick-borne) | Tick |
| Crimean-Congo Hemorrhagic Fever | Tick |
| Boutonneuse Fever | Tick |
| Q-Fever | Tick |
| Murine Typhus | Flea |
| Plague | Flea |
| **Militarily Important Vector-borne Diseases with Long Incubation Periods (>15 days)** | **Vector** |
| Leishmaniasis | Sand Fly |
| Onchocerciasis | Black Fly |
| Bancroftian filariasis | Mosquito |

# Vector Hazard Report Quick Guide: Yemen

| Vector Identification Resources | |
|---|---|
| **Vector** | **Source** |
| Mosquito | WRBU Pictorial Key to the Medically Important Mosquitoes of CENTCOM |
| Mosquito, *Anopheles* | Glick, J.I. 1992. Illustrated Key to the Female Anopheles of Southwestern Asia and Egypt (Diptera: Culicidae). Mosquito Systematics, 24(2): 125-153 |
| Mosquito, *Aedes* | Rueda, L.M. 2004. Pictorial Keys for the Identification of Mosquitoes (Diptera: Culicidae) Associated With Dengue Virus Transmission. Zootaxa, 589: 1-60 |
| Mosquito, *Culex* | Harbach, R.E. 1985. Pictorial keys to the genera of mosquitoes, subgenera of Culex and the species of *Culex* (*Culex*) occurring in southwest Asia and Egypt, with a note on the subgeneric placement of *Culex deserticola* (Diptera: Culicidae). Mosquito Systematics, 17: 83-107 |
| Sand Fly | WRBU Pictorial Key to the Medically Important Sand Flies of CENTCOM |
| Tick, Argasidae | Abdel-Shafy, S., Gabr, H.S., Abdullah, H.H. & Mahmoud, M.S. 2016. Morphological and molecular description of immature stages of *Ornithodoros savignyi* (Acari: Argasidae). Parasitology Research. 115 (8): 3033-3040 |
| Tick, Ixodidae | Hoogstraal, H. & Kaiser, M.N. 1958. The Ticks (Ixodidae) of Iraq: Keys, Hosts and Distribution. Journal of the Iraqi Medical Professions. 6(2/3): 1-22 |
| Black Fly | Dang, P.T. & Peterson, B.V. 1980. Pictorial keys to the main species and species groups within the Simulium damnosum Theobald complex occurring in West Africa (Diptera: Simuliidae). Tropenmedizin und Parasitologie, 31(1): 117-120 |
| Lice | University of Florida, Entomology and Nematology, Featured Creatures: Body Louse |
| Flea | Lewis, R. 1967. The Fleas (Siphonaptera) of Egypt, an Illustrated and Annotated Key. Journal of Parasitology, 53(4): 867-885 |

| Insecticide Resistance Resources |
|---|
| *Aedes* sp. Insecticide Resistance (IR Mapper) |
| *Anopheles* sp. Insecticide Resistance (IR Mapper) |
| Test procedures for insecticide resistance monitoring in malaria vector mosquitoes (WHO) |
| Bottle Assay for Insecticide Resistance (CDC) |

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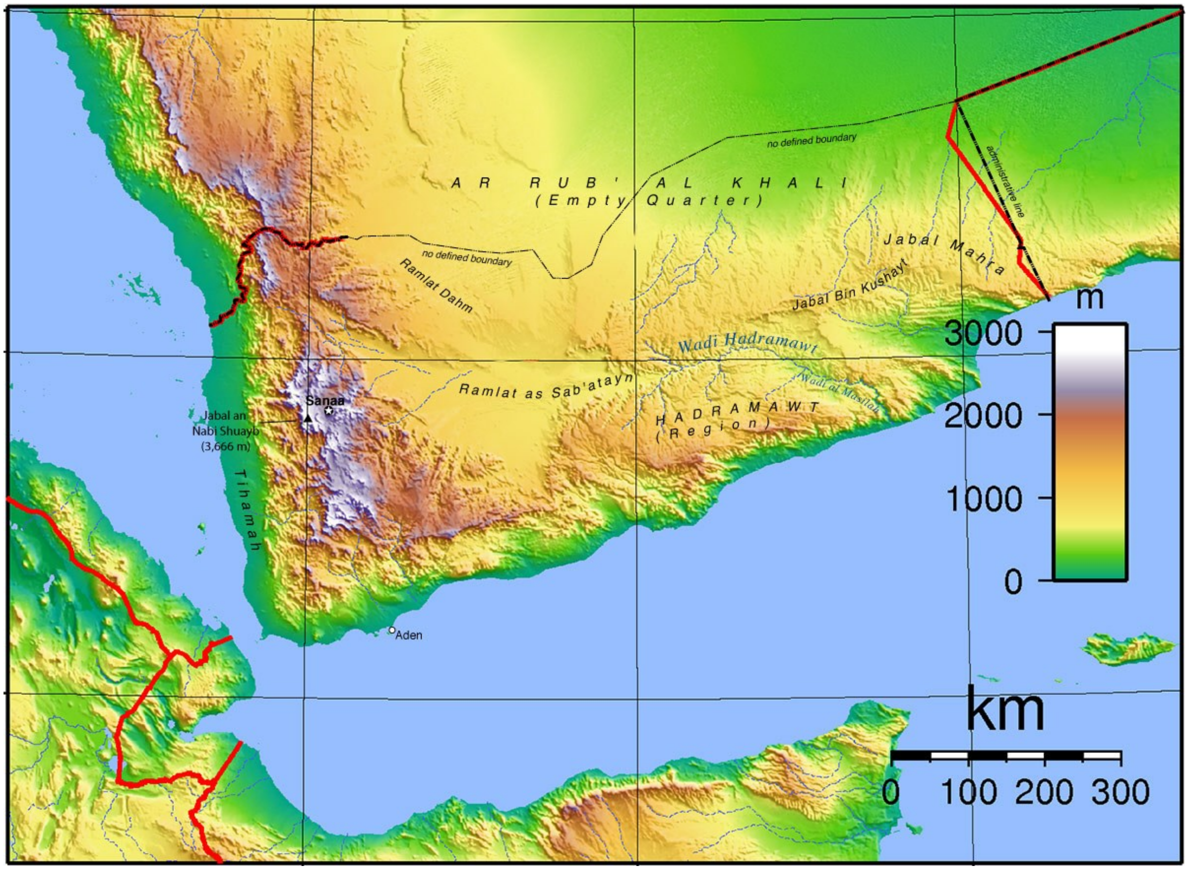
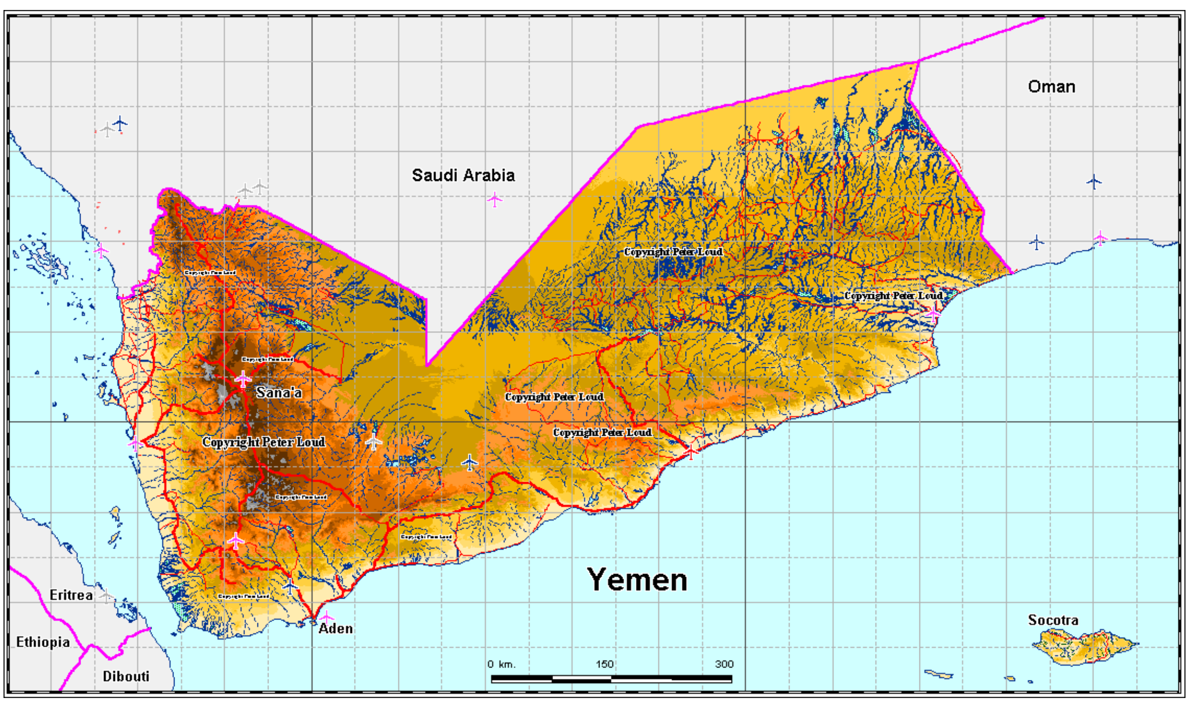
# Maps of Yemen

Explore an interactive map of Yemen displaying current conflicts within the country: [LiveUAMap]
[Mapping the Yemen Conflict: European Council on Foreign Relations]
[Maps of Yemen from the Perry-Castaneda Library (The University of Texas at Austin)]

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# Country Profile: Yemen


CIA Factbook, 2017

**Geography:** Slightly smaller than Texas, Yemen has a land area of 528,000 sq km and can be divided into five physiographic areas: (1) The coastal lowlands, which vary between 6.5 km and 64 km in width, follow Yemen's entire coastline, paralleling the Gulf of Aden to the south and the Red Sea to the west. (2) The highlands are a series of mountains that rise sharply inland from the Gulf of Aden and Red Sea coastal plains, interspersed with jagged valleys, canyons, and low plateaus. Overall elevations are between 460 and 1,400 m above sea level in the western half, increasing in elevation in the eastern half to the highest point in the Arabian Peninsula, 3,800 m above sea level near Sanaa. (3) Further inland, the central plateau contains lowlands less than 1,500 m above sea level and stretches to the east, falling steeply in the north to the desert, and interrupted by several wadi basins in the south. The largest wadi, Hadhramaut, fertile along its upper and middle sections and approximately 200 km inland, is an imposing valley running parallel to the coast of the Arabian Sea. (4) North of the plateau, the northern desert is an extension of the Saudi Arabian Rub al-Khali (Empty Quarter). (5) The islands of Socotra, Peril, and Kamaran make up the remainder of Yemen. View Maps of Yemen section for more information.

**Climate:** Yemen's climate varies over its area. (1) The climate in the coastal zone is hot and humid throughout the year, with maximum daily temperatures between 35C and 41C but occasionally exceeding 54C. This zone receives rainfall only during the summer monsoon season. (2) The highlands have a subtropical climate, with a mean annual temperature of 21C, occasionally dropping close to 0C in winter (October to March). Rainfall primarily occurs from March through May and during August and September. (3) The central plateau has a temperate climate with significant seasonal variations. Winter produces daily lows frequently below 4C, while in summer (April to September) the mean daily temperature is 21C. The Hadhramaut and central highlands receive as much as 500 to 700 mm of rain per year, most falling during summer, when southwest monsoon winds bring intense rains that cause flooding. (4) The climate in the Northern desert region produces a mean daily maximum of 44C and cold nighttime temperatures. Sandstorms occur during summer, with rain only once every 5 to 10 years. Throughout the country, average annual rainfall is only 76 mm, but marked regional differences produce both droughts and floods. View Climate of Yemen section for more information.

**Population and Culture:** Yemenis are mostly rural, with nearly two-thirds of the inhabitants living in small villages and settlements scattered along the coasts and in the Hadhramaut Valley, the Tihama foothills, and the central highlands. The population density is 21 persons per sq km, varying from 46 per sq km in the West to 7 per sq km in the East. The population is 95% Arab, 3% Afro-Arab, and 2% others. Total population is estimated at 28 million (July, 2017); 23% urbanized; literacy rate 38%. Religion: Muslim 99.1% (official; virtually all are citizens, an estimated 65% are Sunni and 35% are Shia), other 0.9% (includes Jewish, Baha'i, Hindu, and Christian; many are refugees or temporary foreign residents) (CIA Factbook, 2010).

**Official Language:** Arabic

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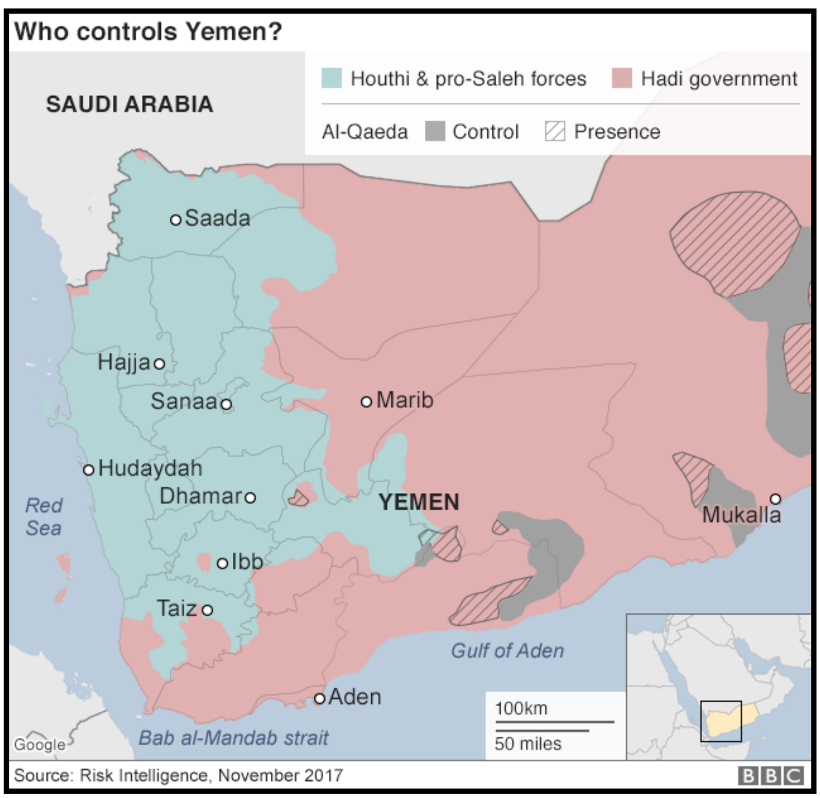
# Country Profile: Yemen, cont.

**Water, Living and Sanitary Conditions:** Yemen is one of the least developed countries in the world. It suffers from scarce, fecal contaminated water sources, indiscriminate waste disposal, and poor food sanitation. Yemen lacks effective water treatment and distribution systems. Municipal water systems provide water to less than 40% of the total population and less than 14% of the rural population. Poor system maintenance, breaks in the lines, and fluctuating water pressure result in contaminated tap water. Adequate sanitation services, including wastewater treatment plants, are limited. Most urban areas are not connected to municipal sewage systems (in Sanaa, only 20% of the population is connected to a sewer system), relying instead on septic tanks, cesspools, and pit latrines. Rural inhabitants indiscriminately dispose of wastes. Refuse accumulates in the streets, attracting vermin. Throughout Yemen there is great potential for the buildup of pest and vector populations associated with human habitations. These could pose a significant disease threat to military personnel.

**Civil Unrest/ Conflict:** There has been an ongoing civil war in Yemen since 2015 between Houthi rebels and government loyalists. Al-Qaeda in the Arabian Peninsula (AQAP) and the Islamic State of Iraq and the Levant have also carried out several attacks in recent years. In 2017, the conflict intensified when ousted president Ali Abdullah Saleh was killed by Houthi rebels in late 2017. Nearly 9,000 people have been killed and nearly 49,000 others injured since the conflict began in 2015. A Saudi Arabian-led multinational coalition supporting the Yemen government have imposed blockades within the country causing widespread food shortages for over 20 million Yemenis (BBC, 2017). In December 2017, the U.S. State Department accused Iran of supplying Houthi rebels with missiles fired into Saudi Arabia in violation of U.N. Security Council resolutions (Lederman, 2017). The CIA Factbook has classified Yemen as a 'Tier 3' country in reference to pervasive issues with human trafficking. For more information about U.S.-Yemeni relations view: Sharp, Jeremy M. 2015. Yemen: Background and U.S. Relations. Congressional Research Service, 7-5700 RL34170




From Yemen Threat Assessment Report, 2017

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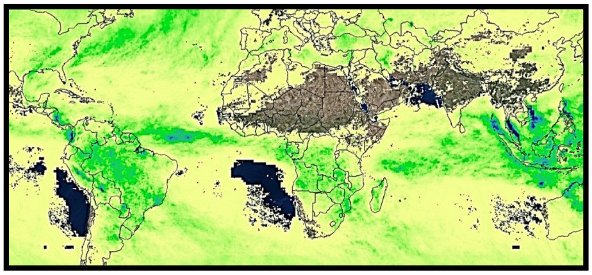
# Monthly Climate Maps

## Click here to view the maps described below

(Updated monthly, NASA Earth Observations, WorldClim)



### Rainfall

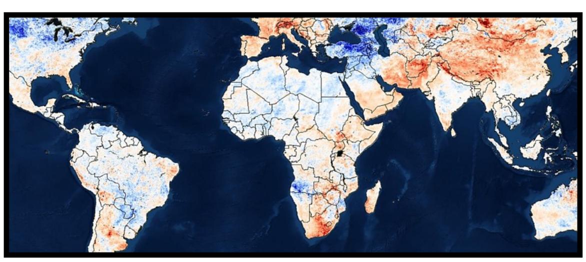
This map displays accumulated rainfall for the past month.

### Consistent Above and Below Average Rainfall

This map displays areas with consistently above or below average monthly rainfall based on the previous three months. Above average rainfall may mean increased  mosquito breeding habitat in areas with poor drainage. Below average rainfall can lead to increased domestic water storage providing increased mosquito breeding habitat.

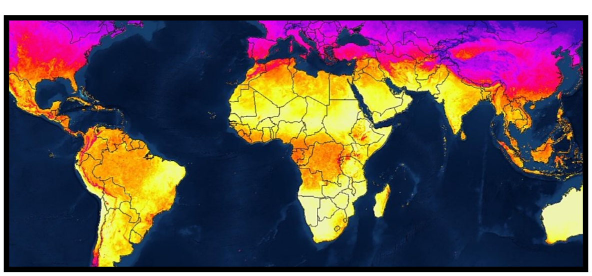
### Drought-Breaking Rain

This map displays areas receiving above average rainfall for the previous month with below average rainfall for the previous 12 months. Drought-breaking rain may indicate suitable conditions for vectors and diseases in a stressed environment or population.



### Temperature Anomaly

This map displays areas where the earth's temperature was warmer or cooler at the surface during the daytime over the expected average monthly temperatures (averaged over 2001-2010).



### Land Surface Temperature

This map displays the temperature of the earths surface during the day-time.

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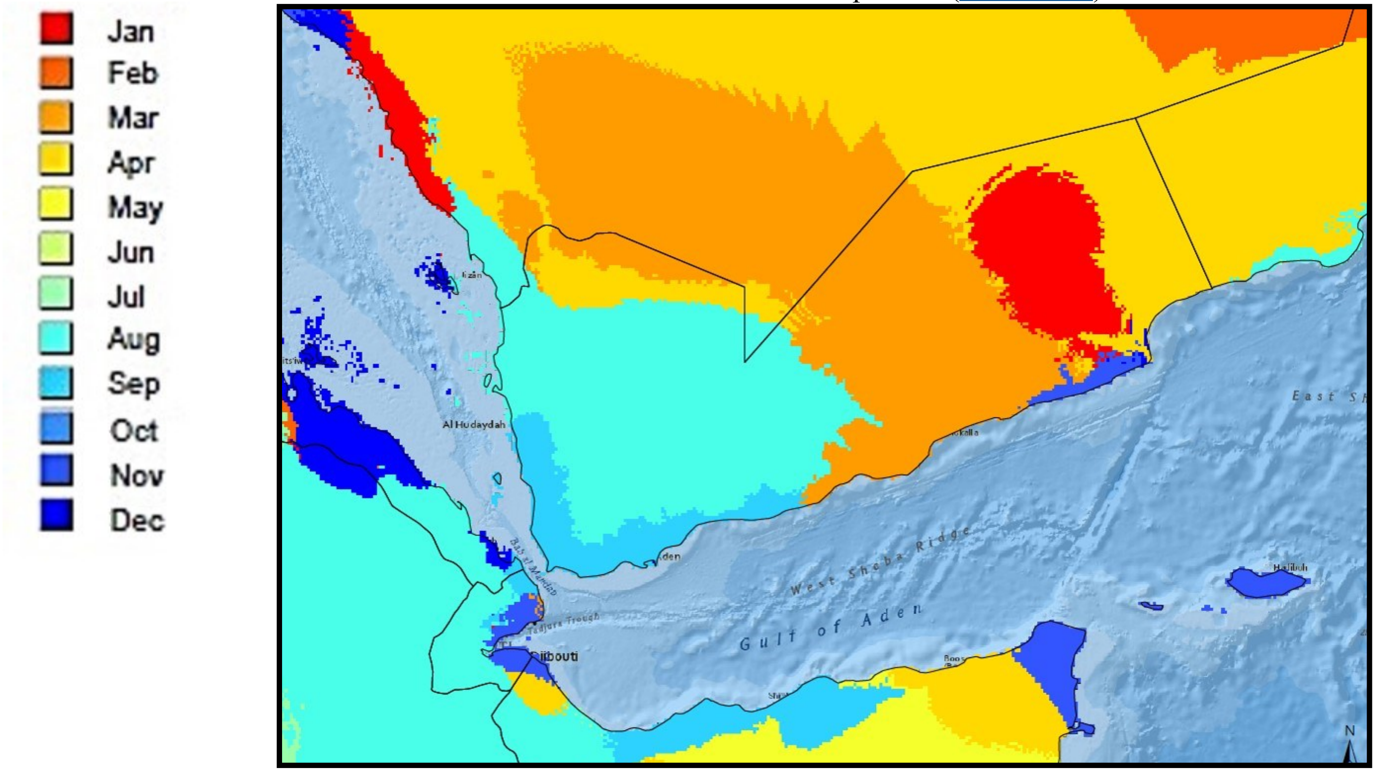
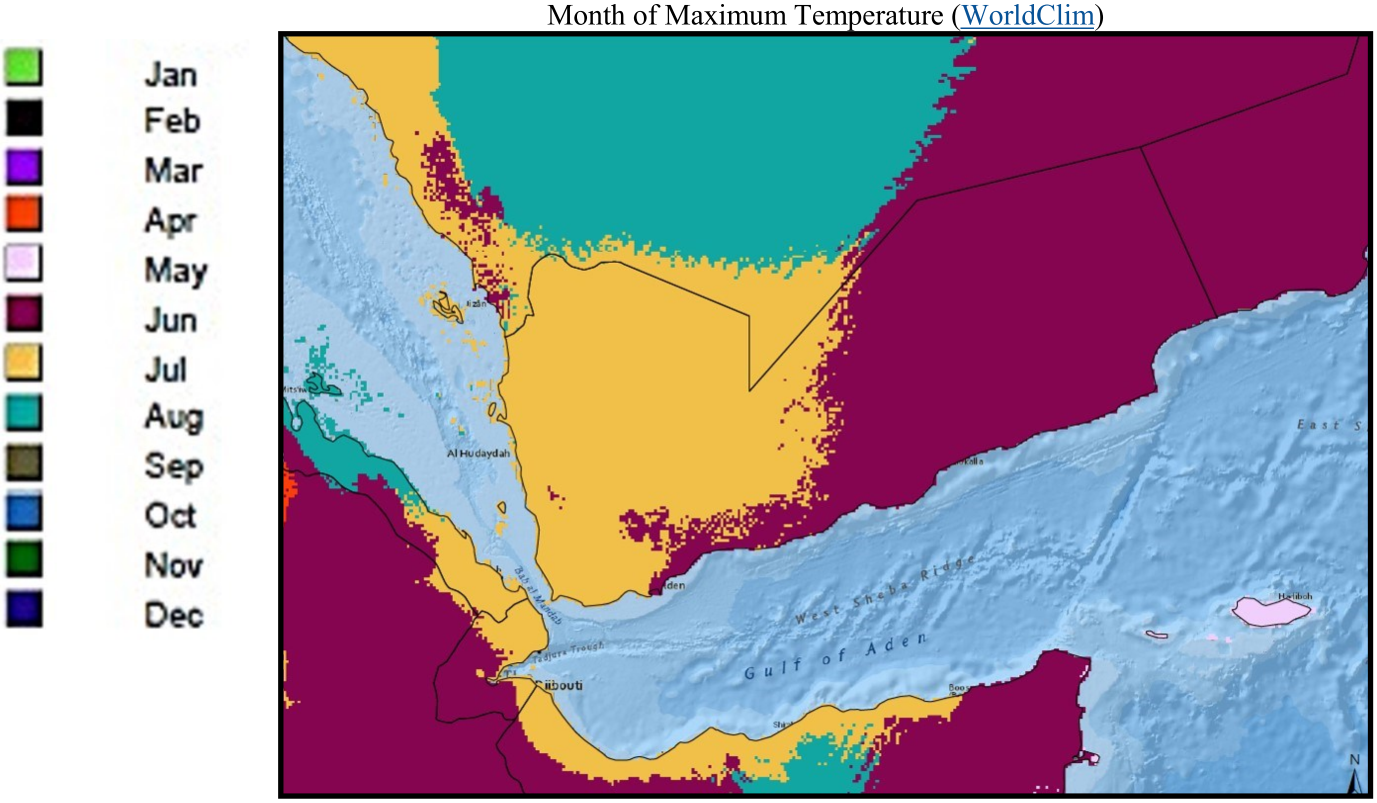
# Climate of Yemen

Month of Maximum Precipitation (WorldClim)




Month of Maximum Temperature (WorldClim)

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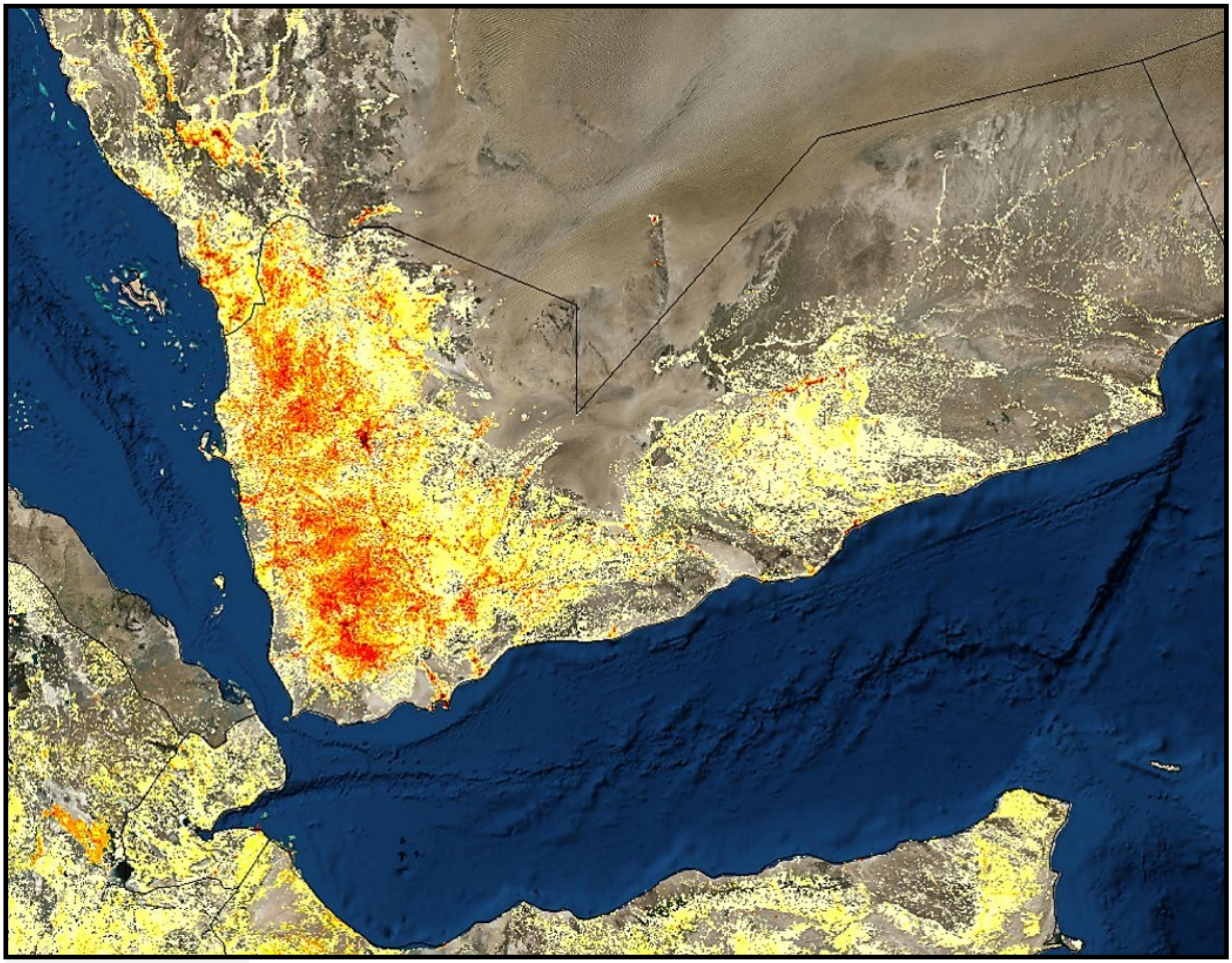
# Host Demographics: Yemen




Human Population/ Sq km, [LandScan 2011]

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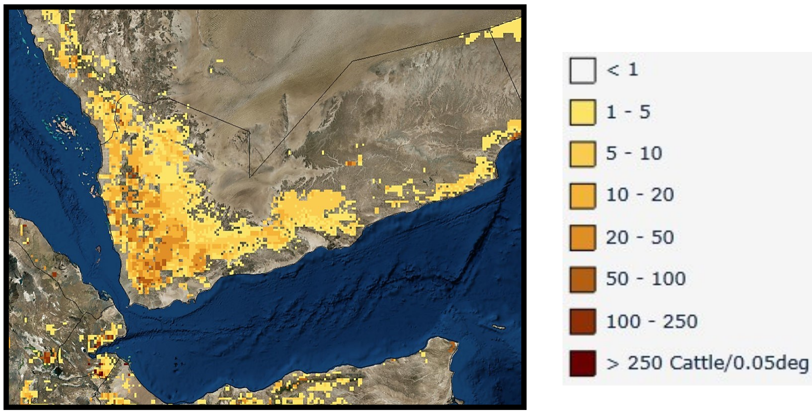
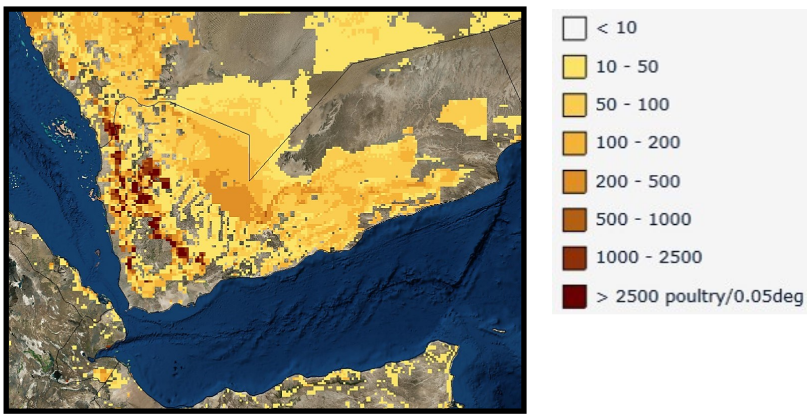
# Host Demographics: Yemen



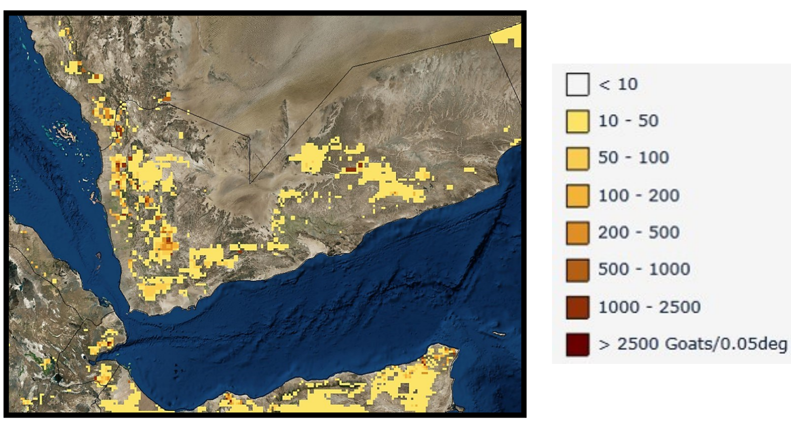

### Cattle Density

Food and Agriculture Organization Animal Production and Health Division predicted number of animals per 0.05 degrees precision, 2005.



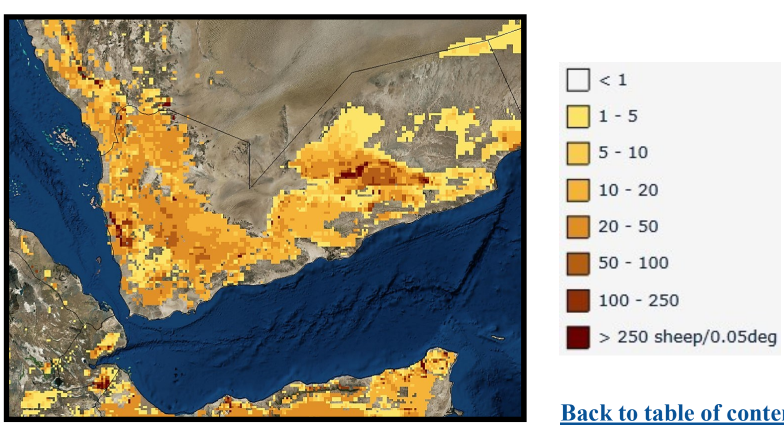

### Poultry Density

Food and Agriculture Organization Animal Production and Health Division predicted number of animals per 0.05 degrees precision, 2005.




### Goat Density

Food and Agriculture Organization Animal Production and Health Division predicted number of animals per 0.05 degrees precision, 2005.




### Sheep Density

Food and Agriculture Organization Animal Production and Health Division predicted number of animals per 0.05 degrees precision, 2005.

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# Vector-borne Disease Hazards

# Malaria

**I. Disease Background:** Human malaria is caused by 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, *Plasmodium falciparum* malaria, can produce life-threatening complications, including renal and hepatic failure, cerebral damage, 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 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. In Yemen, malaria transmission occurs in irrigated agricultural lands, wadis, and urban locales in coastal and foothill areas, including Socotra. Malaria risk is elevated in the southern governorates. Highest levels of transmission occur from October through March. Approximately 90% of all cases are caused by *P. falciparum*, with *P. vivax* and *P. malariae* causing an equal percentage of the remainder.

**II. Military Impact and Historical Perspective:** Historically, malaria has had an epic impact on civilizations and military operations. During World War I, in the Macedonian campaign, the French army was crippled with 96,000 cases of malaria. Malaria caused five times as many US casualties in the South Pacific as did enemy action. In 1942, during World War II, malaria was the major cause of casualties in General Stilwell's forces in North Burma. The Middle East was a notably malarious area during World War II. An annual incidence rate of 65 cases per 1,000 men for the four-year period was recorded. This rate was exceeded only by the incidence of malaria in the China-Burma-India Theater. US forces suffered a total of 273,566 cases of malaria throughout World War II, at a cost of 30,500 combat man-years. In 1952, during the Korean War, the 1st Marine Division suffered up to 40 cases per 1,000 marines. During the Vietnam War, many regiments were rendered ineffective due to the incidence of malaria and many US military units experienced up to 100 cases of malaria per 1,000 personnel per year. Elements of the 73rd Airborne Brigade had an incidence of 400 cases of malaria per 1,000 during 1967 to 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 and disease resurgence in many areas of the world. 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, attack rates of malaria 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 late relapses upon their return to the US. 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.

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# Malaria

**III. Transmission Cycle(s):** Humans are the only reservoir 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 68 (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 and 30o C. Parasite development is prolonged during cool seasons and at high altitudes, and may exceed the life expectancy of the vector. Once infected, mosquitoes remain infective for life. Vector competence is frequently higher with indigenous strains of malaria. This decreases the likelihood that imported strains from migrants will become established.

## IV: Additional Resources:

CDC Malaria Travel Alert

Malaria Atlas Project


Abdel-Shafy, S., Gabr, H.S., Abdullah, H.H. & Mahmoud, M.S. 2016. Morphological and molecular description of immature stages of *Ornithodoros savignyi* (Acari: Argasidae). Parasitology Research. 115(8): 3033-3040.

Al-Taiar, A., Assabri, A., Al-Habori, M., Azazy, A., Algabri, A., Alganadi, M., Whitty, C.J.M. & Jaffar, S. 2009. Socioeconomic and environmental factors important for acquiring non-severe malaria in children in Yemen: a case—control study. Transactions of The Royal Society of Tropical Medicine and Hygiene 103(1): 72-78.

Bamaga, O.A.A., Mahdy, M.A.K. & Lim, Y.A.L. 2014. Malaria in Hadhramout, a southeast province of Yemen: prevalence, risk factors, knowledge, attitude and practices (KAPs). Parasites & Vectors 7:351.

Snow, R.W., Amratia, P., Zamani, G., Mundia, C.W., Noor, A.M., Memish, Z.A., Al Zahrani, M.H., Al-Jasari, A., Fikri, M. & Atta, H. 2014. The malaria transition on the Arabian peninsula: progress toward a malaria-free region between 1960–2010. Advanced Parasitology. 82: 205–251.


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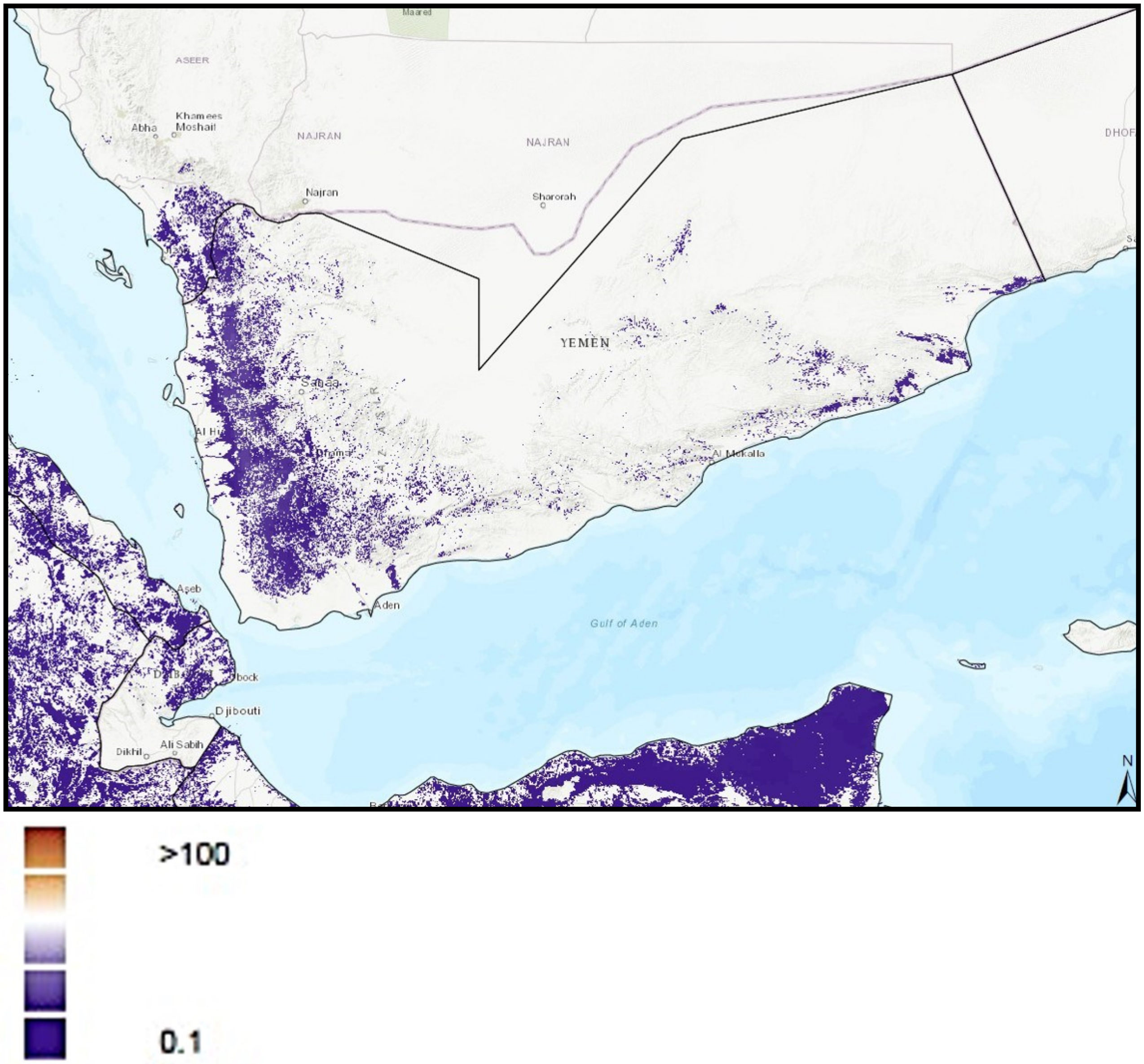
# Malaria

## Disease Distribution




The spatial distribution of Plasmodium falciparum entomological inoculation rate (EIR) IN 2010, Yemen. This map displays predicted number of expected bites from infected mosquitoes per person, per year (Malaria Atlas Project).

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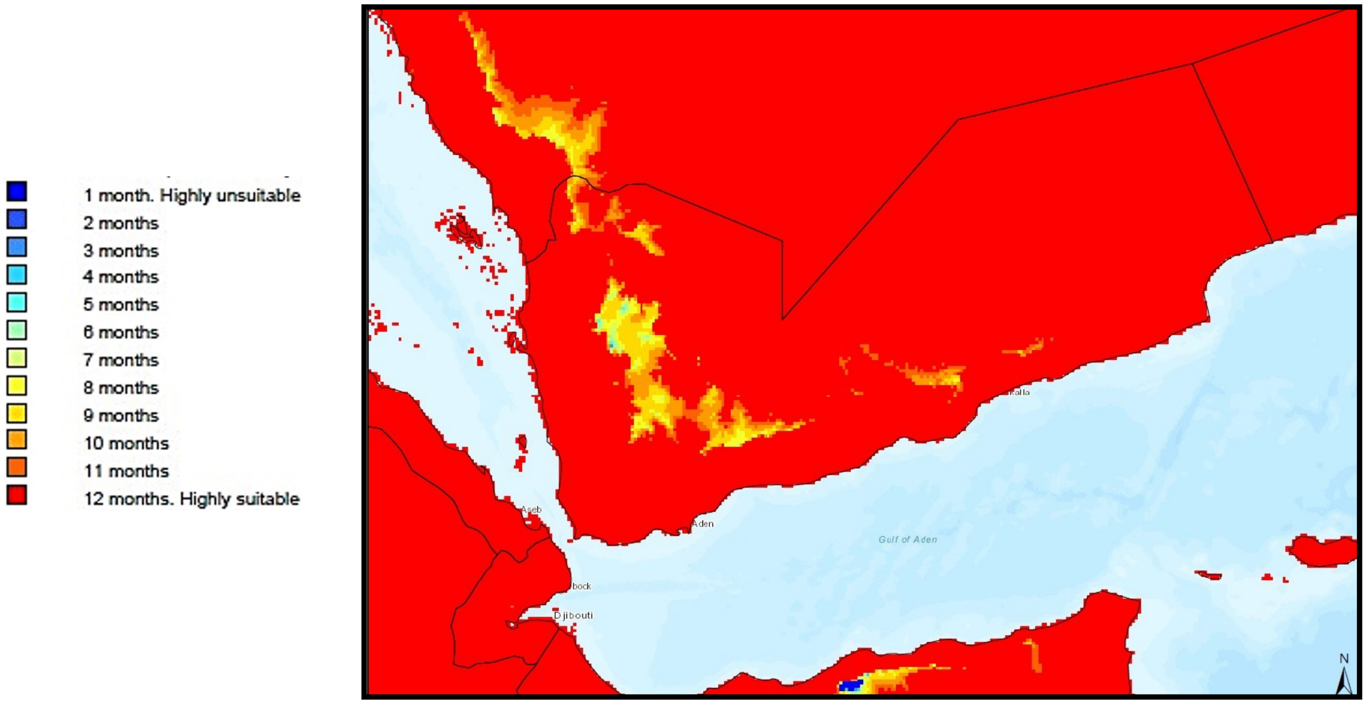
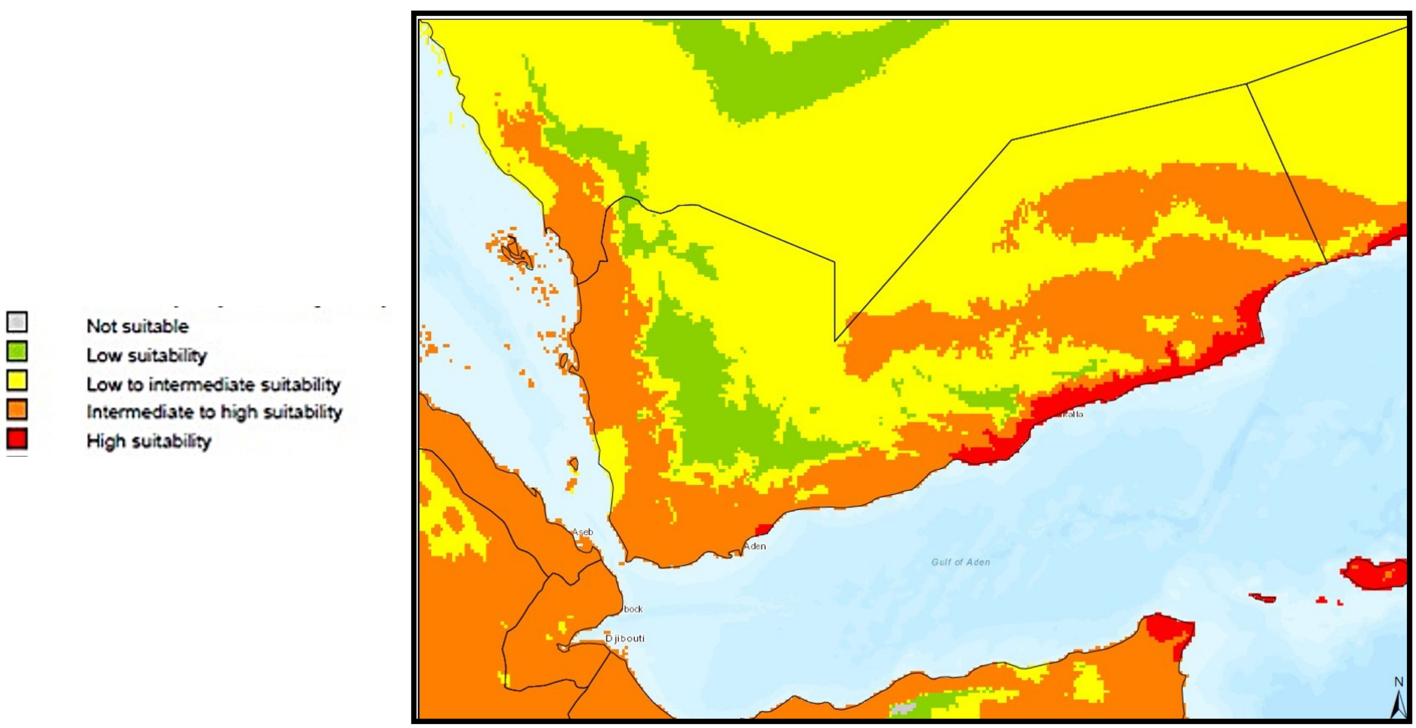
# Malaria: Disease Distribution




The number of days per year which could support *P. falciparum* infectious vectors was calculated using a dynamic biological model and spatial time series temperature data. The temperature data used was a continuous time series across an average year (1950-2000) for every approx. 1 km sq. (Malaria Atlas Project)




Temperature suitability for *P. falciparum* transmission was calculated using a dynamic biological model and spatial time series temperature data. The temperature data used was a time series across an average year (1950-2000) for every approx. 1km sq. (Malaria Atlas Project)

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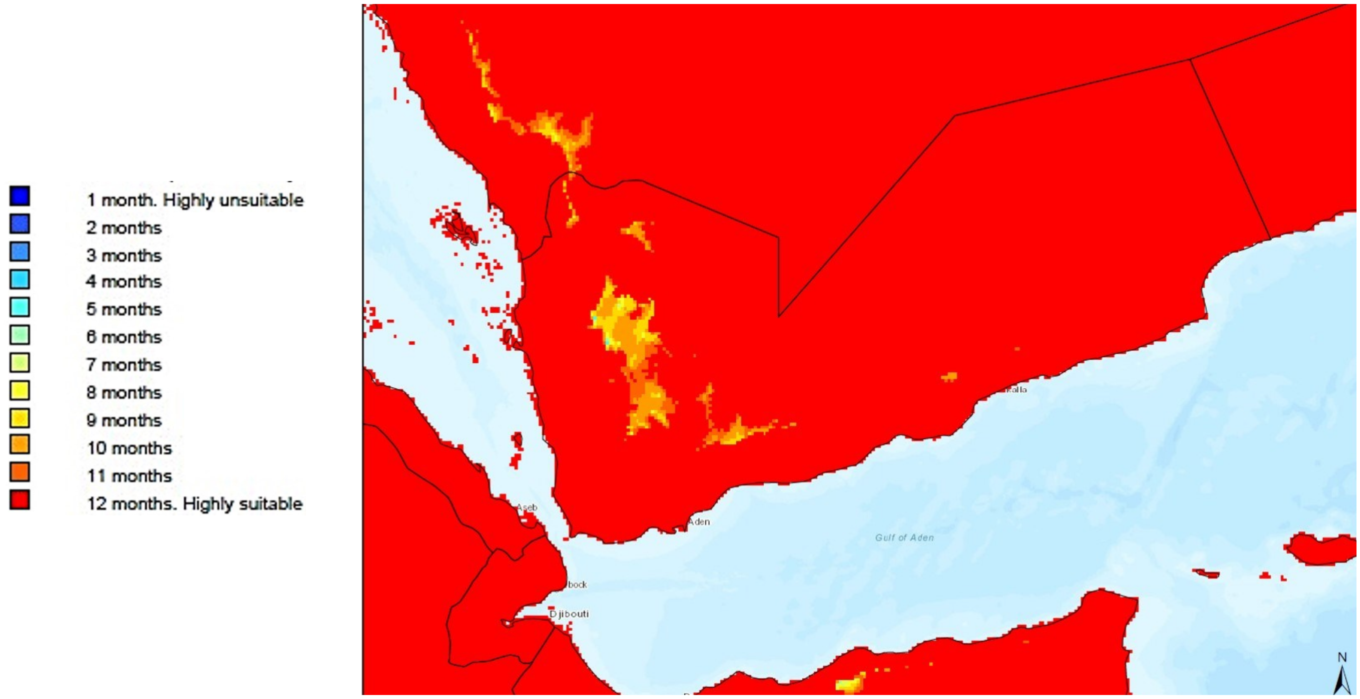
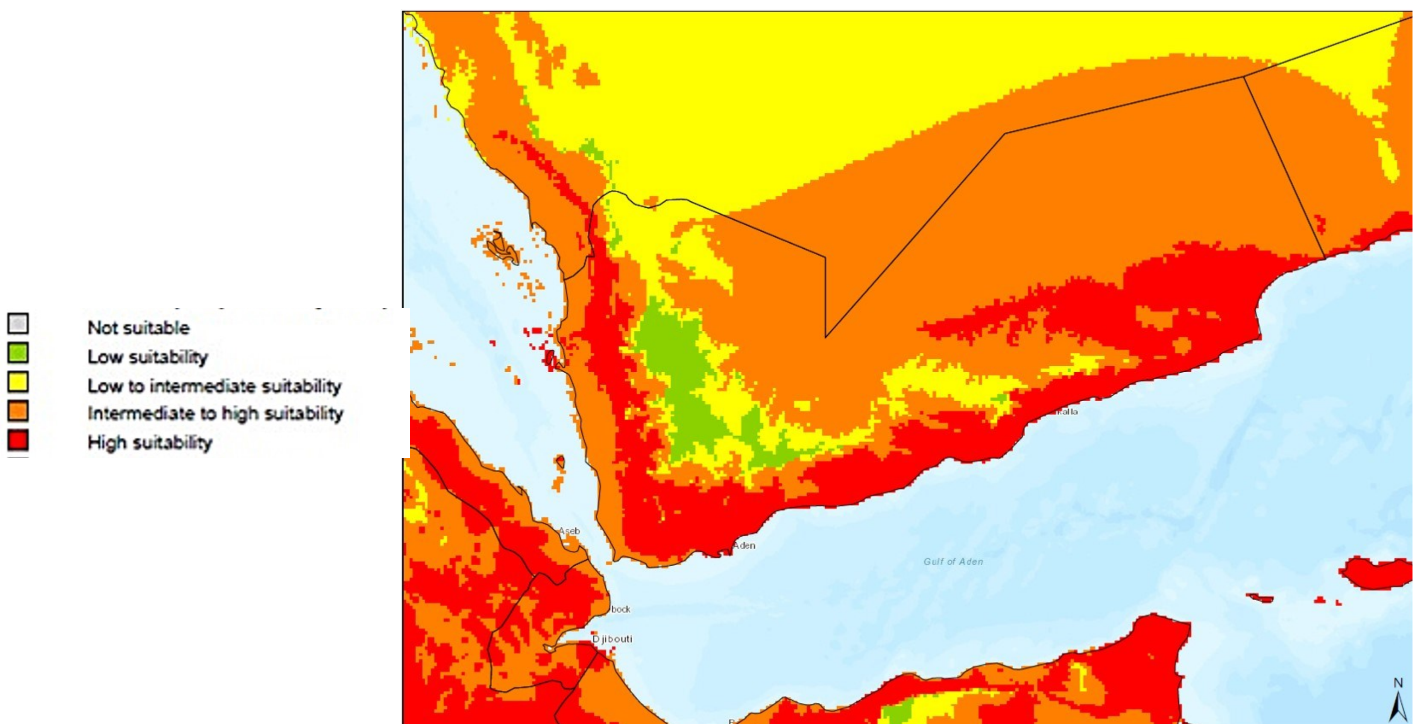
# **Malaria:** Disease Distribution




The number of days per year which could support *P. vivax* infectious vectors was calculated using a dynamic biological model and spatial time series temperature data. The temperature data used was a continuous time series across an average year (1950-2000) for every approx. 1 km sq. ([Malaria Atlas Project](Malaria Atlas Project))




Temperature suitability for *P. vivax* transmission was calculated using a dynamic biological model and spatial time series temperature data. The temperature data used was a time series across an average year (1950-2000) for every approx. 1km sq. (Malaria Atlas Project)

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# Dengue and Chikungunya Viruses

**I. Disease Background:** Dengue fever (Breakbone fever, Dandy fever) is an acute febrile disease characterized by sudden onset, fever for 3 to 5 days, intense headache, and muscle and joint pain. It is 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 four distinct serotypes (dengue 1, 2, 3 and 4). Recovery from infection with one serotype provides lifelong immunity from the same serotype but does not protect against other serotypes. Dengue hemorrhagic fever (DHF) and associated dengue shock syndrome (DSS) were first recognized during a 1954 dengue 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 two serotypes, either sequentially or during a single epidemic involving more than one serotype. DHF is a severe disease that produces high mortality in children. Chikungunya refers to an infection by the Chikungunya virus (CHIKV). CHIKV is known to be transmitted by only two mosquito species, *Ae. aegypti* and *Ae. albopictus*. The name means “that which bends up” in the native language of southeastern Tanzania, and refers to the symptoms of Chikungunya fever. Chikungunya fever (CHIK) symptoms typically include a sudden high fever and severe joint pain. Headache, back pain, muscle pain, nausea, vomiting, arthritis, rash, and conjunctivitis may also occur. Unlike Dengue, CHIK is currently thought to be nonfatal. Outbreaks of CHIKV historically have occurred in Africa and Asia. In 2007, the virus was found to be spreading in northern Italy and in December 2013 was found in the Caribbean. CHIKV has also been detected within populations of refugees fleeing Syria and traveling through Turkey. In 2011, an outbreak of CHIKV was reported from Al-Hudaydah, Yemen.

**II. Military Impact and Historical Perspective:** Dengue virus was first isolated and characterized in the 1940s, but dengue fever had been identified clinically from the 18th century. Epidemics of dengue are noted for affecting a large proportion of the population in a community or in military forces operating in an endemic area. Outbreaks involving 500,000 to 2 million cases have occurred in many parts of the world. During World War II, at Espiritu Santo in the Pacific, an estimated 25% of US military personnel became ill with dengue, causing a loss of 80,000 man-days. Other campaigns in the Pacific were marked by dengue epidemics, and throughout the war the US Army experienced nearly 110,000 cases. Dengue was an important cause of febrile illness among US troops during Operation Restore Hope in Somalia. In recent years dengue, especially DHF, has been expanding throughout the world. Thirty to 50 million cases of dengue are reported annually.

**III. Transmission Cycle(s):** Dengue virus is exclusively 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. Mosquitoes are able to transmit dengue virus 8 to 10 days after an infective blood meal and can transmit the virus for life. Chikungunya virus is also spread via *Aedes* mosquitoes, primarily *Aedes aegypti*.

**IV. Additional Resources:**

CDC Dengue Fever Background

CDC Chikungunya Background

AFPMB Technical Guide No. 47. Aedes Mosquito Vector Control. Office of the Assistant Secretary of Defense (Energy, Installations and Environment). 2016.

Humphrey, J.M., Cleton, N.B., Reusken, C.B.E.M., Glesby, M.J., Koopmans, M.P.G. & Abu-Raddad, L.J. 2017. Urban Chikungunya in the Middle East and North Africa: A systematic review. PLoS Neglected Tropical Diseases. 11(6):e0005707

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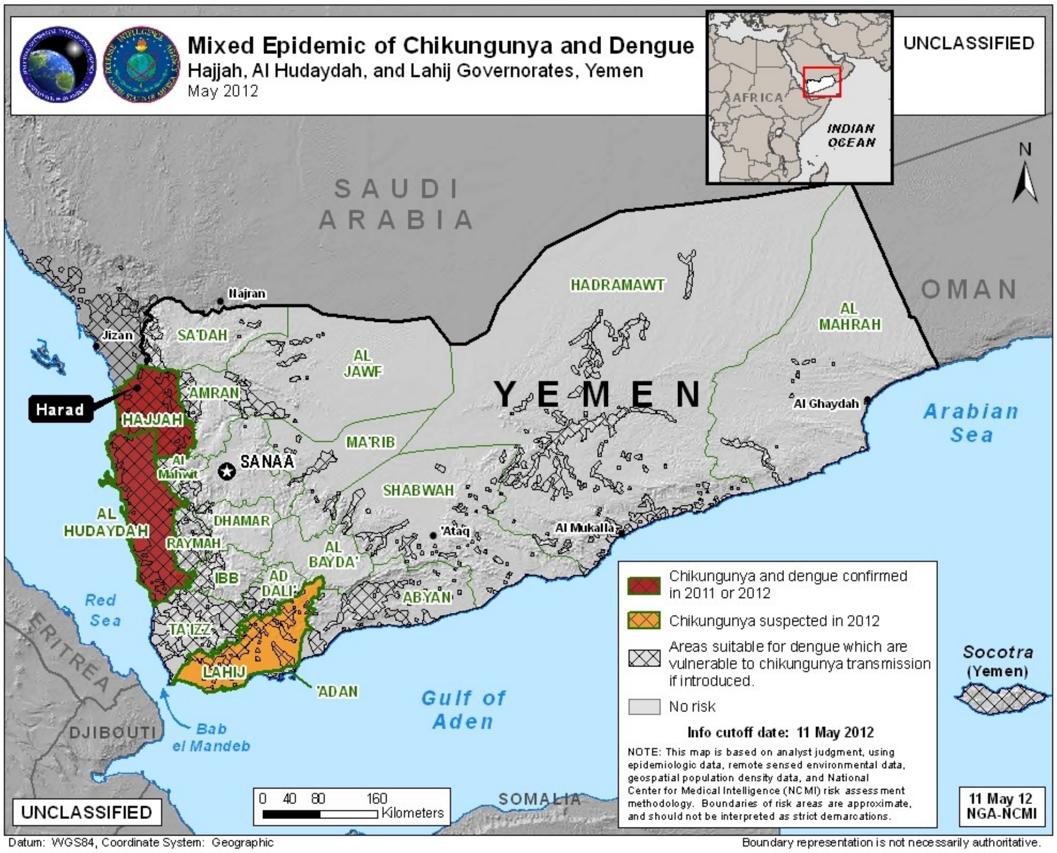
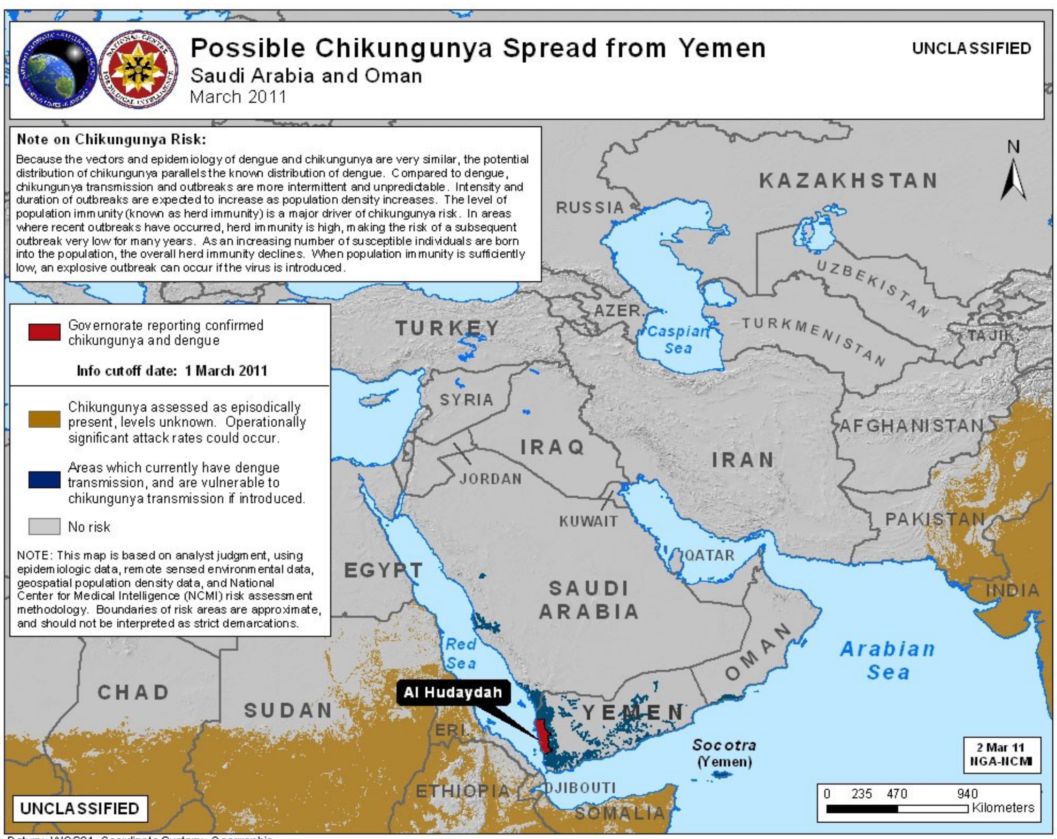
# Dengue Fever and Chikungunya Viruses

## Disease Distribution

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# West Nile Virus

**I. Disease Background:** West Nile fever is a mosquito-borne illness characterized by fever, headache, muscular pain, and rash. Occasionally, serious complications involve the liver and nervous system. The etiological agent, West Nile virus (WNV), is named after the district of Uganda where the virus was first isolated. It is a Flavivirus closely related to viruses causing Japanese encephalitis and St. Louis encephalitis. Infection with WNV is most often asymptomatic. The incubation period ranges from 1 to 6 days and clinically resembles a mild dengue-like illness.

**II. Military Impact and Historical Perspective:** WNV was first isolated in 1937 and was one of the earliest human arboviral infections to be documented. Undoubtedly, WNV has been the cause of many cases classified as fevers of unknown origin in military personnel. In view of the mild illness and the infrequent occurrence of epidemics, the military impact of this illness would be minor, particularly in comparison with other diseases in the Middle East. Infection with WNV will complicate diagnoses by medical personnel, since West Nile fever cannot be clinically distinguished from many other arboviral fevers. Epidemics of West Nile fever are infrequent, and continued long-term surveillance for virus activity can rarely be justified when considering other health care demands. Reduction of mosquito populations by ULV spraying may be useful as a means of disease control. The most feasible long-term control strategies involve reducing vector breeding by environmental management techniques. Personal protective measures to prevent mosquito bites are the most practical means of avoiding infection with WNV.

**III. Transmission Cycle(s):** WNV has been isolated from numerous wild birds and mammals. Serological surveys have demonstrated WNV antibodies in wild and domestic bird species, wild mammals such as lemurs, rodents and bats, and domestic animals such as camels, horses, mules, donkeys, goats, cattle, water buffalo, sheep, pigs and dogs (for host distributions see Host Demographics page). However, birds are considered to be the primary reservoir for WNV and may reintroduce the virus during seasonal migrations. Infections in most mammals fail to produce viremias high enough to infect potential vectors. WNV has been isolated from several species of mosquitoes in nature, and they are recognized as the major vectors, especially *Culex* spp. WNV has also been recovered from bird-feeding ticks and mites. A natural bird-tick zoonotic cycle has been suggested, but the role of ticks in the natural transmission of WNV has not been well defined. Mosquitoes are clearly implicated in the transmission of WNV to humans. WNV replicates quickly in mosquitoes when temperatures exceed 25C. Infected mosquitoes can transmit WNV for life.

**IV. Additional Resources:**

CDC West Nile Virus Background

Qaseem, M., Jaawel, A., Basalh, A., Bin Break, A., Al-Serouri, A. & Qayad, M. 2014. Mixed outbreak of Dengue and West Nile virus, Yemen, 2013. 16th International Congress on Infectious Diseases 2014.


Countries reporting West Nile virus infection, CDC 2000

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# Sindbis virus

**I. Disease Background:** Sindbis virus belongs to the genus *Alphavirus* in the family Togaviridae. It is closely related to the Western equine encephalitis complex. The incubation period is less than a week and symptoms may include fever, headache, rash, and joint pain. Syndromes resulting from Sindbis virus infection have been called Ockelbo disease in Sweden, Pogsta disease in Finland, and Karelian fever in the former Soviet Union. No fatal cases have been reported.

**II. Military Impact and Historical Perspective:** Sindbis virus was first isolated in 1952 from *Culex* mosquitoes collected in the village of Sindbis north of Cairo. A role in human disease was recognized in 1961 when Sindbis virus was isolated from patients with fever in Uganda. Although outbreaks of Sindbis virus have caused significant human morbidity in areas of northern Europe and South Africa, this disease is expected to have minor impact on military operations in the Middle East.

**III. Transmission Cycle(s):** A wide range of wild and domestic vertebrate species are susceptible to infection with Sindbis virus. Most experimentally infected wild bird species easily produce viremias high enough to infect several different species of mosquitoes. Wild and domestic birds are considered the main enzootic reservoir. Although several species of domestic animals can become infected with Sindbis virus, there is no evidence that these infections result in significant illness. Evidence implicates bird-feeding mosquitoes of the genus *Culex* as the vectors of Sindbis virus in enzootic and human infections. However, viral isolations and transmission experiments have shown that *Aedes* spp., which are less host specific and feed readily on both birds and humans, may be important as vectors linking the enzootic cycle with human infection. Mechanisms that allow the virus to overwinter and survive between periods of enzootic transmission have not been identified.

**IV. Additional Resources:**

ECDC Sindbis Virus Background

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# Rift Valley Fever Virus

**I. Disease Background:** A Phlebovirus of the family Bunyaviridae causes Rift Valley fever (RVF). Humans infected with RVF typically have either no symptoms or a mild illness associated with fever and liver abnormalities. However, in some patients the illness can progress to hemorrhagic fever with shock or hemorrhage, encephalitis with coma or seizures, and/or ocular disease. Patients who become ill usually experience fever, generalized weakness, back pain, dizziness and weight loss at onset of fever. Typically, patients recover within one week after onset of illness. The most common complication associated with RVF is inflammation of the retina resulting in permanent vision loss in 1 to 10% of affected patients. Approximately 1% of patients die of the disease, but case fatality rates are significantly higher for infected animals. Nearly 100% of pregnant livestock infected with RVF virus abort their fetuses. There is no established course of treatment for infected patients, although some antiviral drugs such as ribavirin show promise.

**II. Military Impact and Historical Perspective:** Veterinary officers in Kenya first reported RVF among livestock in the early 1900s, although the virus wasn't isolated until 1930. The most notable epizootic occurred in South Africa during 1950 to 1951 and was estimated to have caused the death of 100,000 sheep and cattle and to have involved 20,000 human cases. A major epizootic occurred in Kenya at the same time. In 1977, the virus was detected in Egypt and caused a large outbreak among animals and humans. The first epidemic of RVF in West Africa was reported in 1987 and was linked to the Lower Senegal River Project. The project caused flooding in the lower Senegal River area that produced large populations of mosquitoes. During epizootics, RVF could seriously affect military operations. Five percent of Swedish United Nations Emergency Forces soldiers serving in Egypt and the Sinai peninsula were infected with RVF virus during the 1977-78 epidemic in Egypt. Medical personnel should be aware of clinical and diagnostic procedures to differentiate RVF from other fevers with similar clinical syndromes.

**III. Transmission Cycle(s):** RVF primarily affects domestic animals such as cattle, buffalo, sheep, goats and camels (for host distributions see Host Demographics page). High viremias occur in infected humans. Thus, humans, as well as domestic animals, could be a source of virus to infect potential vectors. Mosquitoes transmit RVF virus. Unlike most arboviruses that are associated with either a single species or closely related group of mosquitoes, RVF virus has been isolated from at least 28 species in six genera of mosquitoes. Epizootics have generally occurred during years of excessive rainfall and localized flooding that produced large populations of mosquitoes. RVF virus may be transmitted by other blood-sucking arthropods. *Culex pipiens* was implicated as the principal vector during the 1977-78 epidemic in Egypt. Laboratory studies have shown *Aedes caspius*, *Culex perexiguus* and *Cx. antennatus* are competent vectors. Vector competence studies and knowledge of mosquito density and feeding behavior in areas where RVF virus infections have occurred suggest that these species may be the principal vectors involved in domestic animal transmission and as bridge vectors from domestic animals to humans. In contrast, *Cx. pipiens* appears to be the principal vector for human-to-human transmission. Transovarial transmission of the virus is known to occur in some mosquito species. Humans can also acquire infection if they are exposed to the blood or other body fluids of infected animals. This exposure can result from the slaughtering or handling of infected animals or by touching contaminated meat during the preparation of food. Abattoir workers are a useful sentinel population for surveillance of RVF virus. Laboratory infection through aerosol transmission of RVF virus has resulted from exposure to specimens containing the virus.

**IV. Additional Resources:**

CDC Background: Rift Valley Fever Virus

# Bancroftian filariasis

**I. Disease Background:** Bancroftian filariasis is caused by the nematode *Wuchereria bancrofti*, which normally resides in the lymphatic system of infected humans. After 8 to 12 months, adult female worms release thousands of microfilariae into the circulatory system. Females continue to produce microfilariae over the next 15 to 18 years. Many individuals are asymptomatic in the early stages of infection. The disease 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. Death of numerous microfilariae resulting from drug therapy may cause severe immune reactions.

**II. Military Impact and Historical Perspective:** Microfilariae of *W. bancrofti* were discovered in the blood of a patient in Brazil in 1866. This was the first discovery of a pathogen that is transmitted by insects. Over 70 million people worldwide are estimated to be infected by *W. bancrofti*, resulting in serious economic costs to developing countries. The long incubation period and requirement for multiple infections over a long period of time before the appearance of clinical symptoms render chronic 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 symptoms such as swelling of the lymph glands, headache and fever many months before larvae become mature. American military forces in the Samoan-Ellice-Wallis Islands from 1942 to 1944 rapidly developed swollen lymph glands and 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. In addition, observing local members of the population 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.

**III. 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 its geographic range, including the Middle East, *W. bancrofti* microfilariae usually 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 quinquefasciatus* is the most common urban vector. In rural areas, transmission is maintained mainly by *Anopheles* spp. There are no known animal reservoirs of Bancroftian filariasis. Seasonal distribution generally coincides with rainy periods in endemic areas. Transmission in the principal foci of Yemen and Southwestern Saudi Arabia is from April to August.

**IV. Additional Resources:**

[CDC Background Lymphatic filariasis]

[WHO Background Lymphatic filariasis]


Distribution of Filariasis in the Middle East (AFPMB, 1999)

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# Sand Fly Fever

**I. Disease Background:** Sand fly fever is caused by two distinct Phlebovirus serotypes, Naples and Sicilian. The virus produces an acute febrile illness lasting 2 to 4 days and is commonly accompanied by headache and muscle pain. There is usually no mortality or significant complications. Most infections are acquired during childhood in endemic areas. The clinical disease in children is generally mild and results in lifelong immunity.

**II. Military Impact and Historical Perspective:** Sand fly fever has been an important cause of febrile disease during military operations since at least the Napoleonic Wars. In 1909, an Austrian military commission first reported that an agent found in the blood of infected soldiers caused this fever, and that the vector was the sand fly. During World War II, there were 19,000 cases of sand fly fever, with the highest incidence reported in the Middle East Theater. In sharp contrast to World War II, there were no reports of sand fly fever among coalition forces during the Persian Gulf War. The military significance of sand fly fever is magnified because of its short incubation period, which may result in large numbers of nonimmune troops being rendered ineffective early in an operation, while endemic forces would be largely immune and unaffected.

**III. Transmission Cycle(s):** No vertebrate reservoir has been established, but there is some serological evidence that gerbils serve as reservoirs. Infected humans can infect sand flies and thus have an amplifying effect during epidemics. The principal reservoir mechanism appears to be transovarial transmission within the vector. The virus is most efficiently replicated in the sand fly vector and transmitted when temperatures exceed 25° C. Infected sand flies remain infective for life and are not harmed by the virus.

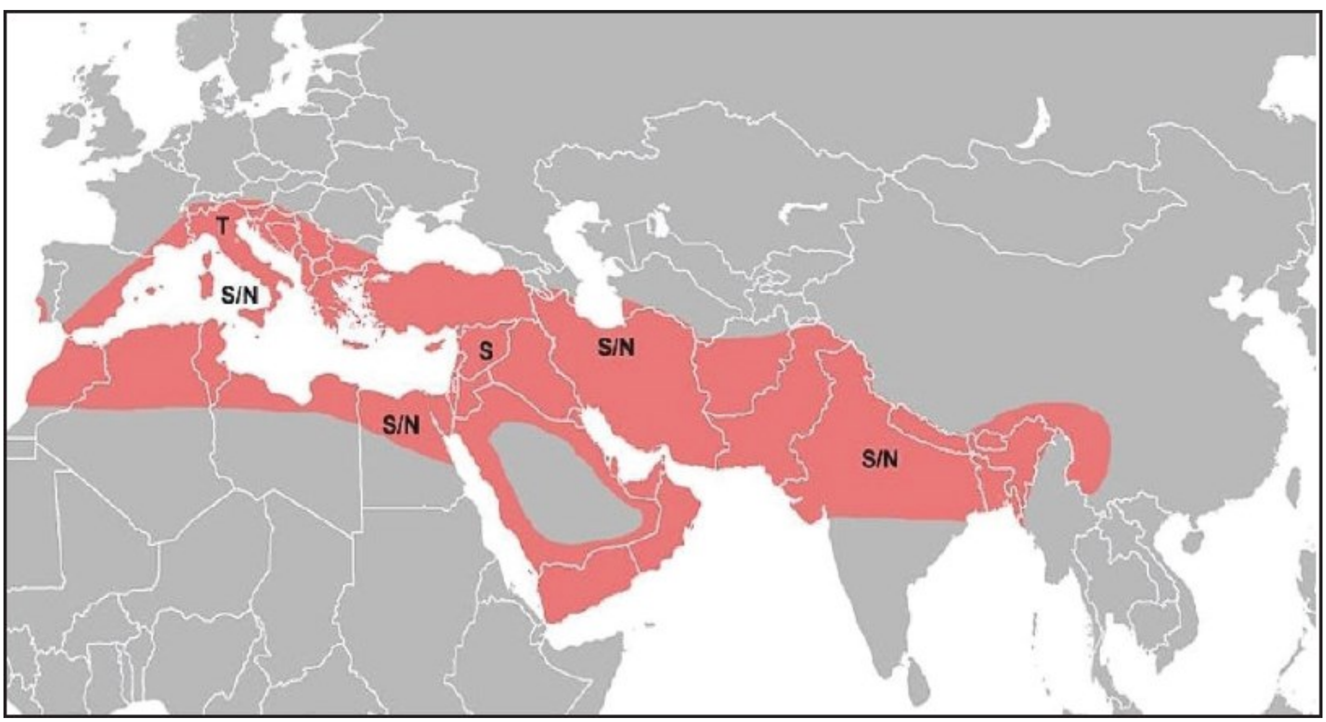
**IV. Additional Resources:**


Tavana, A.M. 2015. Sand fly fever in the world. Annals of Tropical Medicine and Public Health. 8(4): 83-87.

Torun, E.C., Çağlayık D.Y., Uyar, Y., Korukluoğlu, G., Ertek, M. 2010. Sandfly fever outbreak in a province at Central Anatolia, Turkey. Mikrobiyol Bul. 44(3): 431-439.

Tufan, Z.K. & Tasyaran, M.A. 2013. Sandfly fever: A mini review. Virol Mycol 2:109.


**Distibution of Sand Fly fever by serotype: T, Toscana, S, Sicilian; N, Naples (Tavana, 2015)**

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# Leishmaniasis

**I. Disease Background:** 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. All vectors of leishmaniasis in the Old World are in the sand fly genus *Phlebotomus*. Incubation in humans may take as little as ten days, or more than six months. Symptoms include ulcerative cutaneous lesions (cutaneous leishmaniasis or CL), 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). In the Middle East, both CL and VL are important public health problems. CL (Baghdad boil, Jericho boil, Oriental sore), caused by infection with *Leishmania major* or *Le. tropica*, typically appears as a nonhealing ulcer. The lesion usually develops within weeks or months after a sand fly bite and slowly evolves from a papule to a nodule to an ulcer. Cutaneous lesions may resolve quickly (2-3 months) without treatment or they may become chronic (lasting months to years) and will seldom heal without treatment. Scarring is associated with healing. In endemic areas, such scars are common among both rural and urban populations. Life-long immunity to the infecting Leishmania species normally results. VL (Kala-azar, Dum Dum fever), is the most severe form of leishmaniasis, with as much as 95% mortality in untreated cases. It is a chronic disease and, without treatment, is marked by fever (2 daily peaks), weakness and, as the parasites invade internal organs, weight loss coupled with enlargement of spleen and liver that may resemble severe malnutrition. 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 concern. In the Old World, VL is usually attributed to *L. donovani* or *L. infantum*. Viscerotropic *L. tropica* has also been reported and was described in veterans of the Persian Gulf war. The incubation period for VL is usually 4 to 6 months but may be as short as 10 days or as long as two years. By the time the disease is diagnosed, patients have usually forgotten any contact with sand flies. In endemic regions it is a disease of the young and old, who succumb to it disproportionately. Epidemics of VL often follow conditions of severe drought, famine or disruption of native populations by wars that produce large numbers of refugees.

**II. Military Impact and Historical Perspective:** Although not a war stopper, leishmaniasis is a persistent health threat to U.S. military personnel because troops deploy or conduct military exercises in locations where the disease is endemic. The overall potential for this disease to compromise mission objectives is significant. CL is highly endemic in the Middle East, and in some areas 80-90% of the people bear leishmanial scars. Soldiers exposed to sand fly bites while deployed to the region are highly susceptible to infection with Leishmania. Immunity among US military personnel is essentially nonexistent, and recovery from CL does not confer immunity to VL. In the Karum River Valley of Iraq, US forces suffered 630 cases of the disease in a 3-month period during WWII. During the 1967 "Six Day War," Israeli soldiers camped near Jericho in the Jordan Valley suffered a 50% attack rate of *Le. major*. In the northern Sinai desert, 113 cases of *Le. major* were reported from Multinational Forces and observers from 1973 through 1991. In 1990-91, twenty cases of CL due mainly to *Le. major* and 12 cases of VL due to *Le. tropica* were diagnosed when 697,000 allied soldiers were deployed to the Arabian Peninsula during Operations Desert Shield and Storm. Even though no fatalities were associated with leishmaniasis in this deployment, new lessons were learned that could affect future military deployments. Before the Persian Gulf War, eastern Saudi Arabia was not known to be endemic for visceral leishmaniasis and *L. tropica* was not convincingly shown to produce visceral disease. More importantly, the potential for leishmaniasis to cause intransigent post-deployment diagnostic problems and threaten blood supplies had not been anticipated. Returnees from the Persian Gulf War were barred from donating blood for up to two years, severely impacting blood supplies. Infection with Leishmania was even listed as one of the causative agents of Persian Gulf War syndrome, but scientific evidence for this association is lacking. Diagnosis of leishmaniasis is difficult at best, and providing proper care for service members who may have been exposed or infected is a long, costly and complex process.

**III. Transmission Cycle(s):** *Le. major* is a parasite of colonial desert rodents, especially gerbils such as the fat sand rat, *Psammomys obesus*. Female *Phlebotomus papatasi* inhabit the burrow systems of these rodents and acquire infections while feeding on their rodent hosts. Amastigotes (the mammalian form of the Leishmania parasite) ingested with the bloodmeal transform to a flagellated promastigote form within the gut of the female fly. In addition to a bloodmeal, the female fly seeks and consumes sugar from the plants in the area during subsequent nocturnal flights. These sugars help maintain Leishmania infections in the flies. Promastigotes multiply in the gut of the sand fly within the bloodmeal and undergo development to an infective form called the metacyclic promastigote. By the time the bloodmeal is digested and the fly is ready to lay its eggs, infective metacyclic promastigotes are ready to be transmitted to the next vertebrate host when the sand fly feeds again. In *Le. major* foci, where the principal reservoirs are colonial rodents, humans are considered accidental or incidental hosts, becoming infected when their habitat overlaps that of the rodent host. In urban *Le. tropica*, humans may serve as reservoirs. In rural areas, non-human hosts of *Le. tropica* may include wild and domestic rodents living in close proximity to humans.

**IV. Additional Resources:**

CDC Background Leishmaniasis

WHO Background Leishmaniasis

Jacobson, R.L. 2011. Leishmaniasis in an era of conflict in the Middle East. Vector-Borne and Zoonotic Diseases: 11(3): 247-258.

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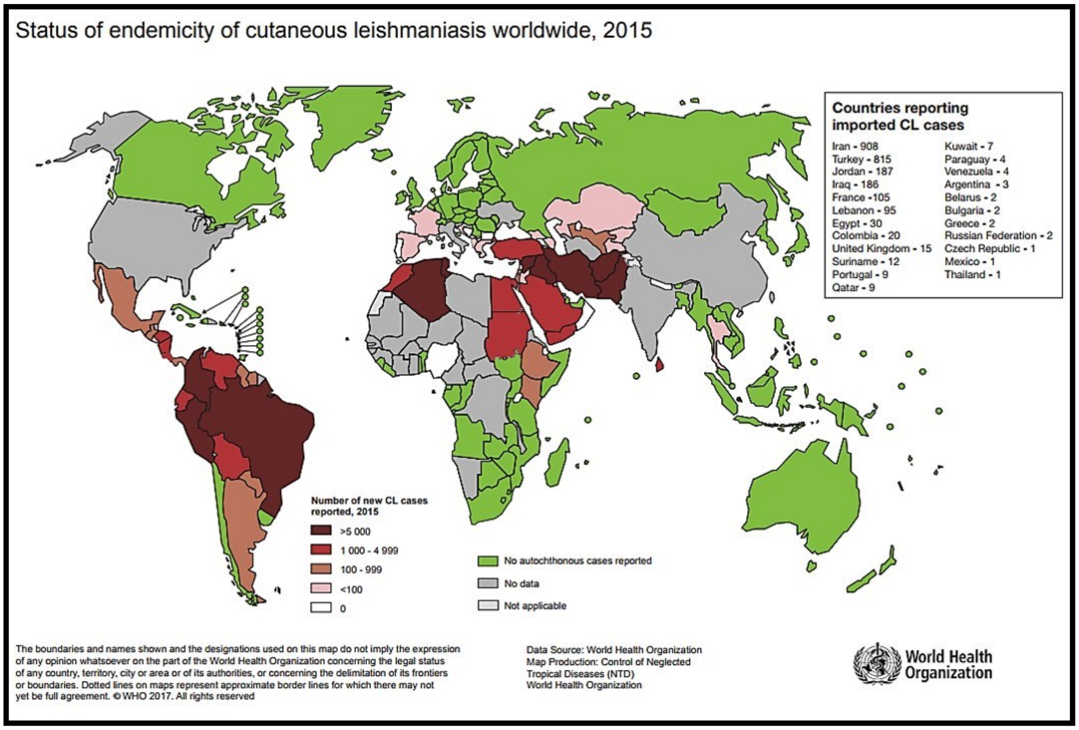
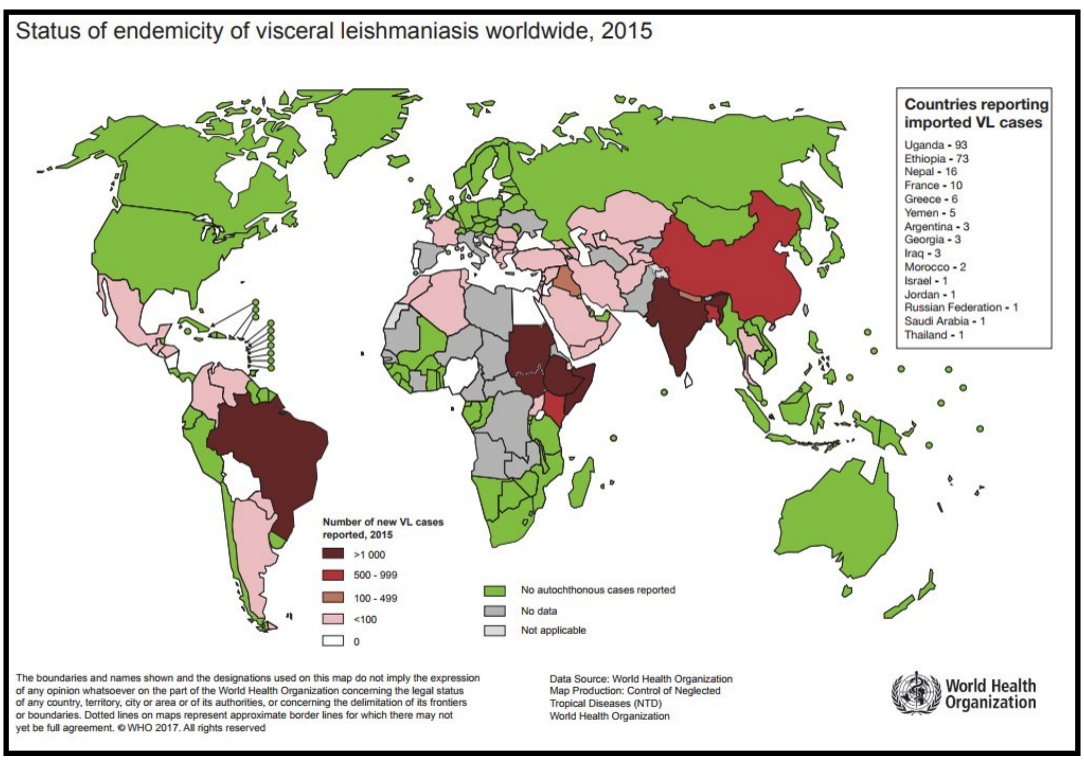
# Leishmaniasis

## Disease Distribution

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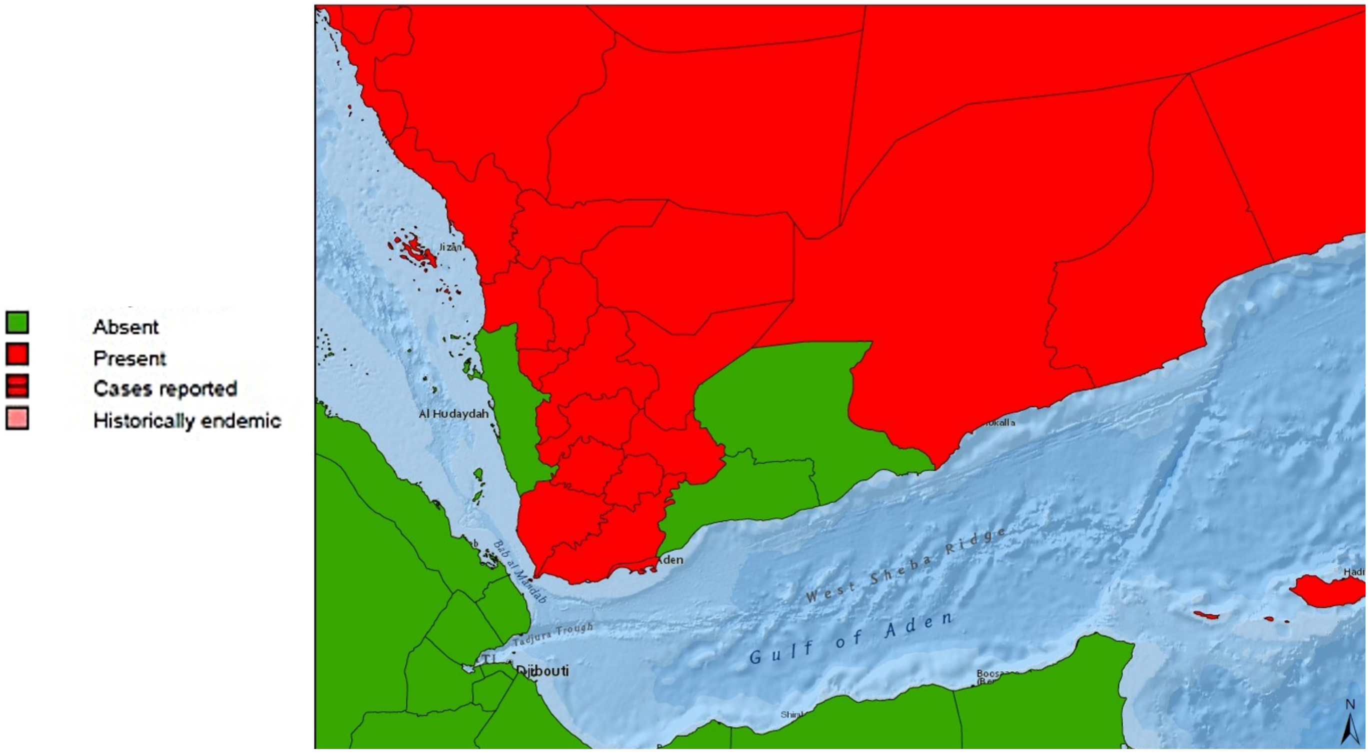
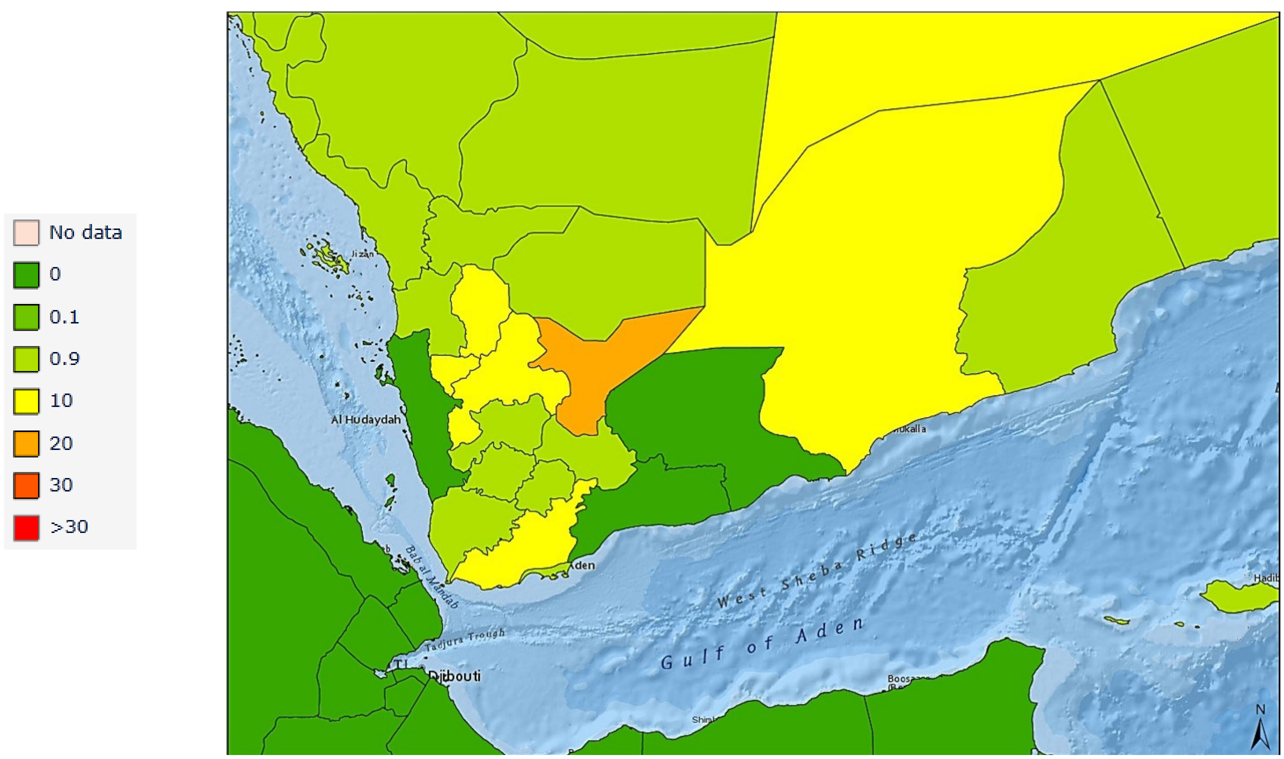
# Leishmaniasis: Disease Distribution




Cutaneous Leishmaniasis presence. Alvar J. et al. 2012.




Cutaneous Leishmaniasis estimated maximum number of cases 2012. Alvar J. et al. 2012.

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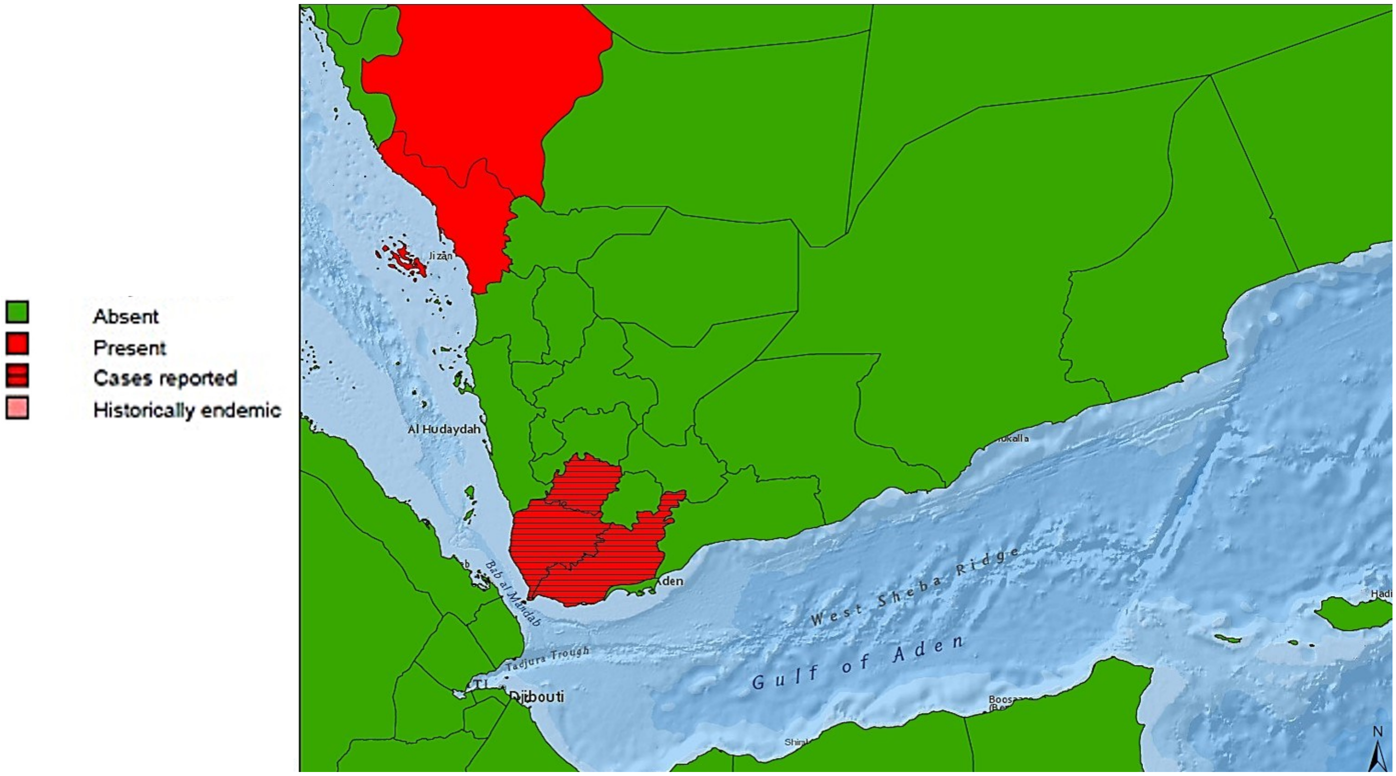
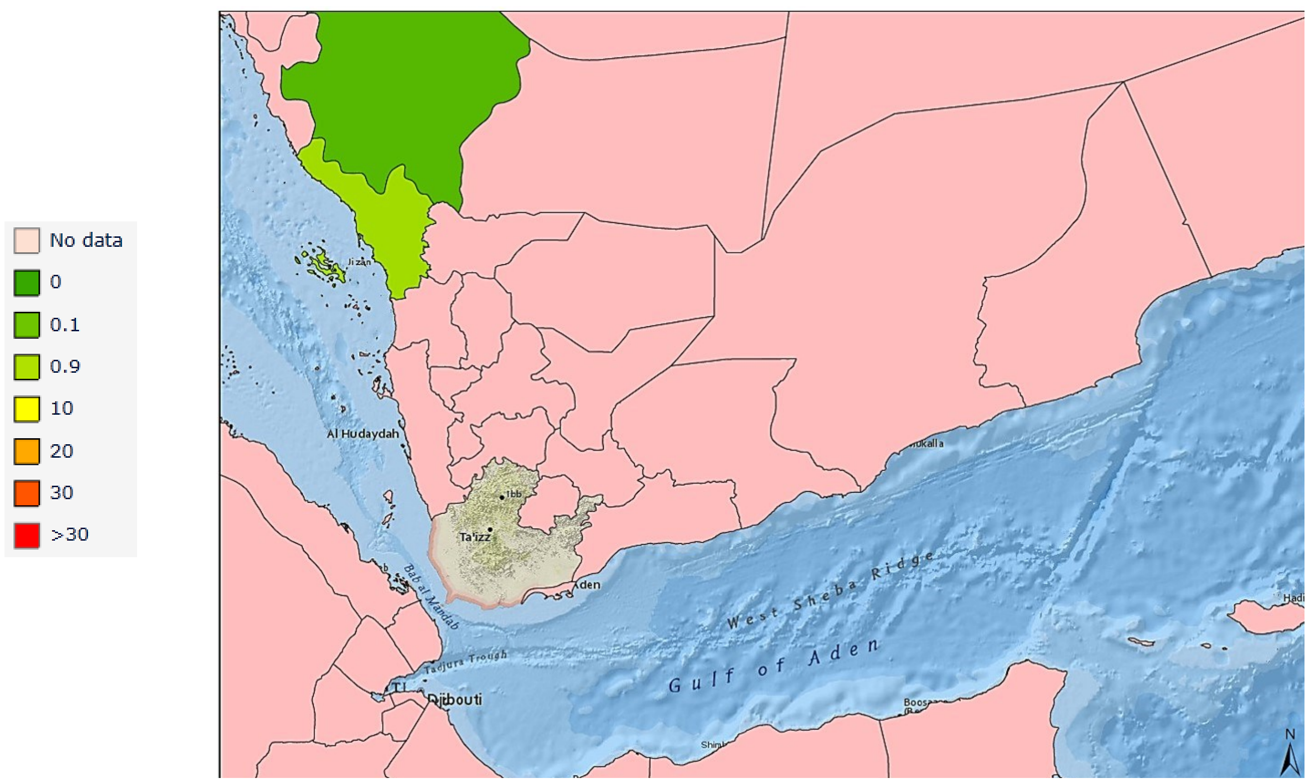
# **Leishmaniasis** Disease Distribution




Visceral Leishmaniasis presence. Alvar J. et al. 2012.




Visceral Leishmaniasis estimated maximum number of cases 2012. Alvar J. et al. 2012.

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# Crimean-Congo Hemorrhagic Fever (CCHF)

**I. Disease Background:** CCHF is a zoonotic disease caused by a tick-borne virus of the family Bunyaviridae. The disease is characterized by febrile illness with headache, muscle pain and rash, frequently followed by a hemorrhagic state with hepatitis. The mortality rate can exceed 30%. The incubation period ranges from 3 to 10 days. CCHF may be confused clinically with other hemorrhagic infectious diseases.

**II. Military Impact and Historical Perspective:** Descriptions of a disease compatible with CCHF can be traced back to antiquity in eastern Europe and Asia. CCHF was first described in soldiers and peasants bitten by ticks of the genus *Hyalomma* while working and sleeping outdoors in the Crimean peninsula in 1944. The virus was first isolated in 1967. Since there are no available treatment regiments of proven value and recovery from CCHF can be very protracted, military personnel with CCHF require significant medical resources.

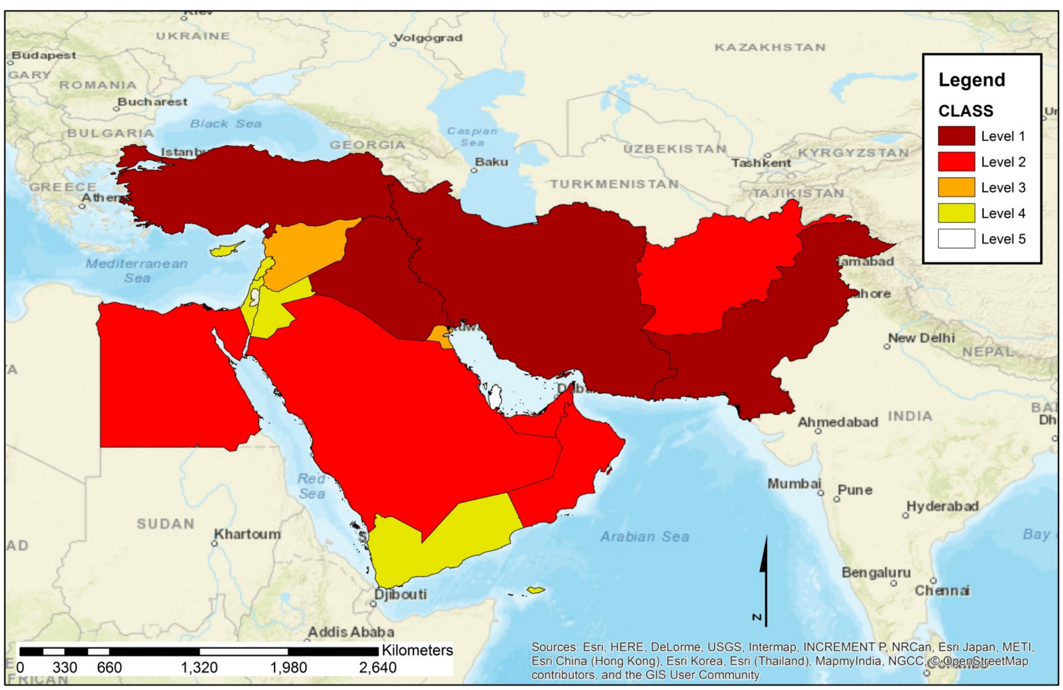
**III. Transmission Cycle(s):** CCHF virus has been isolated from at least 30 species of ticks. From experimental evidence it appears that many species of ticks are capable of transmitting the virus, but members of the genus *Hyalomma* are the most efficient vectors. The aggressive host-seeking behavior of adult hyalommines makes these ticks ideal vectors. The highest prevalence of antibodies in wild and domestic reservoirs has been found in arid areas where *Hyalomma* sp. are common. Antibodies to CCHF virus are widespread in large wild and domestic herbivores. Domestic ruminants generally acquire infection early in life. Viremia in livestock is short-lived and of low intensity. Antibodies or virus have been found in a variety of small mammals, including hares, hedgehogs and rodents. Transovarial transmission of virus in vector ticks is an important reservoir mechanism. Humans acquire CCHF virus from tick bites, from contamination of broken skin or mucous membranes with crushed tissues or feces of infected ticks, or from contact with blood or other tissues of infected animals. CCHF virus is highly infectious, and nosocomial infection of medical workers has been important in many outbreaks. CCHF virus loses infectivity shortly after the death of an infected host. There is no indication that consumption of meat processed according to normal health regulations constitutes a hazard.

**IV. Additional Resources:**

CDC Background CCHF

WHO Background CCHF

**CCHF Burden Predictions in Europe and Southern and Western Asia**




**Level 1:** These countries are CCHF-endemic with different levels of surveillance systems in place.
**Level 2:** These countries have had occasional CCHF cases reported. They require the most robust active surveillance systems to identify hot spots and increase public awareness.
**Level 3:** Ecological data supporting CCHFV circulation, although no cases are reported. Identification of undiagnosed human cases is needed.
**Level 4:** The only supporting evidence for CCHFV circulation is the existence of Hyalomma ticks. Given their proximity to CCHF-endemic countries, the chance of CCHFV circulation is appreciable. Future epidemiologic studies should include serosurveys and tick surveys.
**Level 5:** In the absence of available information, presence or absence of Hyalomma ticks requires further study.

Source: Blair, Paul; Polanco-Ramos, Aileen; Kortepeter, Mark; Kuhn, Jens H.; Pecor, David; Apanaskevich, Dmitry; Rivard, Robert; Keshtkar-Jahromi, Maryam. 2017. Using the One Health Approach to Map Endemicity and Emergence of Crimean-Congo Hemorrhagic Fever in Europe, Southern and Western Asia. American Society of Tropical Medicine and Hygiene, 2017 Meeting, Poster Session.

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# Relapsing Fever (Tick-borne)

**I. Disease Background:** 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. A number of species of *Borrelia* are responsible for the disease. The taxonomy of the pathogen is complex. The close vector-spirochete relationship has led to the definition of most spirochete species by the tick vector. There is great strain variation among tick-borne *Borrelia*, and a single strain can give rise to many serotypes. Some authorities view all species as tick-adapted strains of the louse-borne relapsing fever spirochete, *B. recurrentis*.

**II. 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 low incidence of the disease.

**III. Transmission Cycle(s):** Soft ticks of the genus Ornithodoros transmit tick-borne relapsing fever. Infection is transmitted from human to human, animal to animal, or from animal to man by the bite of infective ticks. Rodents are sources of infection for ticks, although ticks are more important as long-term reservoirs. The pathogen has been maintained naturally in some species of ticks 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. Spirochetes can pass into bite wounds or penetrate unbroken skin. Exposure to infected blood of patients can cause infections in medical personnel. Sporadic cases have been reported from Yemen where vector ticks commonly infest caves, bunkers and tombs.

**IV. Additional Resources:**

CDC Background Relapsing Fever

Dworkin, M.S., Schwan, T.G., Anderson, D.E. Jr & Borchardt, S.M. 2008. Tick-Borne Relapsing Fever. Infectious Disease Clinics of North America. 22(3): 449-468.

# Relapsing Fever (Louse-borne)

**I. Disease Background:** Louse-borne relapsing fever is caused by the spirochete *Borrelia recurrentis*. The symptoms and severity of relapsing fever depend on the immune status of the individual, geographic location, and strain of *Borrelia*. The incubation period in an infected host ranges from 2 to 14 days. The disease is characterized by a primary febrile attack followed by an afebrile interval and one or more subsequent attacks of fever and headache. Intervals between attacks range from 5 to 9 days. In untreated cases, mortality is usually low but can reach 40%. Infection responds well to treatment with antibiotics.

**II. Military Impact and Historical Perspective:** Major epidemics of louse-borne relapsing fever occurred during World War I and the war's aftermath in Russia, Central Europe and North Africa. After the war, relapsing fever was disseminated through large areas of Europe, carried by louse-infested soldiers, civilians and prisoners of war. Between 1910 and 1945, there were an estimated 15 million cases and nearly 5 million deaths. Large outbreaks of relapsing fever were common during and after World War II. During the Vietnam War, epidemics of louse-borne fever also occurred in the Democratic Peoples' Republic of Vietnam.

**III. Transmission Cycle(s):** The body louse, *P. h. humanus*, is the vector of *B. recurrentis*. After the louse feeds on infective blood, the spirochetes leave the digestive tract and multiply in the insect's body cavity and other organs. They do not invade the salivary glands or the ovaries. Bites and infective feces cannot transmit the pathogen, and transovarial transmission does not occur. Human infection occurs when a louse is crushed and *Borrelia* spirochetes are released. The spirochetes may be scratched into the skin, but there is evidence that *B. recurrentis* can penetrate unbroken skin. Since infection is fatal to the louse, a single louse can infect only one person. However, *B. recurrentis* can survive for some time in a dead louse. Outbreaks of louse-borne relapsing fever require high populations of body lice. Lice leave febrile patients in search of new hosts, and this behavior contributes to the spread of disease during an epidemic. Sporadic cases of louse-borne relapsing fever have been reported from Iran and Iraq, but endemic foci may also exist elsewhere in the Middle East where body louse infestations are common. Imported cases from North Africa have been reported. Epidemics usually occur in the cold season, among poor people with inadequate hygiene.

**IV. Additional Resources:**

ECDC Background Louse-borne Relapsing Fever

Rahlenbeck, S.I. & Gebre-Yohannes, A. 1995. Louse-borne relapsing fever and its treatment. Tropical Geographic Medicine. 47(2): 49-52.

Raoult, D. & Roux, V. 1999. The body louse as a vector of reemerging human diseases. Clinical Infectious Diseases. 29(4): 888-911.

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# Boutonneuse Fever

**I. Disease Background:** (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 and caused by *Rickettsia conorii* and closely related organisms. Different strains of *R. conorii* have been isolated from ticks and humans. The common name of this disease comes from the button-like lesions, 2 to 5 mm in diameter, that develop at tick attachment sites. The disease caused by strains of *R. conorii* in Israel lacks this characteristic skin lesion and is more severe than disease caused by other strains. With antibiotic treatment, fever lasts no more than 2 days. The case fatality rate is very low, even without treatment.

**II. Military Impact and Historical Perspective:** Boutonneuse fever has not significantly interfered with military operations in the past. Sporadic cases among combat troops can be expected in limited geographic areas. The severity of illness depends on the strain of *R. conorii* contracted. Because the spotted fevers are regional diseases, military medical personnel newly assigned to an area may be unfamiliar with them and diagnosis may be delayed.

**III. Transmission Cycle(s):** The disease is maintained in nature by transovarial passage of the pathogen in ticks, primarily the brown dog tick, *Rhipicephalus sanguineus*, although almost any *Ixodes* sp. may harbor the pathogen. Enzootic infection in dogs, rodents and other animals is usually subclinical. Transmission to humans is by bite of infected ticks. Contamination of breaks in the skin or mucous membranes with crushed tissues or feces of infected ticks can also lead to infection.

**IV. Additional Resources:**

CDC Background Rickettsial (Spotted & Typhus Fevers) & Related Infections

Okulicz, J.F. 2016. Boutonneuse Fever. Medscape.com

Rovery, C., Brouqui, P. & Raoult, D.. 2008. Questions on Mediterranean spotted fever a century after its discovery. Emerging Infectious Diseases. 14(9): 1360-1367.

# Query Fever (Q fever)

**I. Disease Background:** 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. Infections may be unapparent or present as a nonspecific fever of unknown origin. The case fatality rate in untreated acute cases is less than 1%.

**II. 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. Thousands of cases of Q fever occurred in US troops during World War I, and the disease caused epidemics in the armies fighting during World War II. Three cases of Q fever were recorded in US military personnel during the Persian Gulf War.

**III. Transmission Cycle(s):** In nature there are two cycles of infection with *C. burnetii*. One involves arthropods, especially ticks, and a variety of wild vertebrates. The other cycle is maintained among domestic animals. Although humans are rarely, if ever, infected by ticks, arthropods may transmit infection to domestic animals, especially sheep and cattle. Domestic animals have unapparent infections but shed large quantities of infectious organisms in their urine, milk, feces, and especially their placental products. Because *C. burnetii* is highly resistant to desiccation, light and extremes of temperature, infectious organisms become aerosolized, causing widespread outbreaks in humans and other animals, often at a great distance from 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. Outbreaks of Q fever in humans have been traced to consumption of infected dairy products, contact with contaminated wool or hides, infected straw, and infected animal feces. *C. burnetii* may enter through minor abrasions of the skin or the mucous membranes. Although rare, human-to-human transmission of Q fever has occurred. Q fever is widespread across the Middle East region.

**IV. Additional Resources:**

CDC Background Q Fever

Maurin, M. & Raoult, D. 1999. Q Fever. Clinical Microbiology Review. 12(4): 518-553.

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# Plague (Pestis, Black Death)

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

**II. Military Impact and Historical Perspective:** Epidemics of plague have been known since ancient times and have profoundly affected civilization. During the Middle Ages, Europe experienced repeated pandemics of plague. Twenty-five percent of the continent's population died during the great pandemic of the 14th century. The last pandemic of plague originated at the close of the 19th century in northern China and spread to other continents by way of rats on steamships. Plague has been a decisive factor affecting military campaigns, weakening besieged cities or attacking armies during the Middle Ages. Severe ecological disturbances and dislocations of human populations during the Vietnam War led to outbreaks of plague. Even though plague has been declining on a worldwide basis, persistent enzootic foci can trigger the recurrence of epidemics when general sanitation and health services are disrupted by war or natural disaster. Presently, the threat of plague to military operations is low.

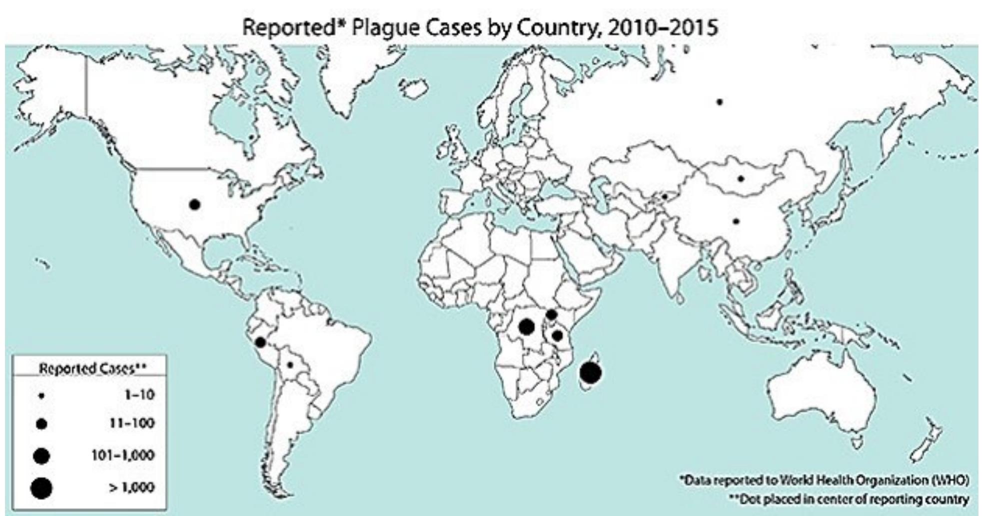
**III. Transmission Cycle(s):** Plague is a disease of rodents. It is maintained in nature among wild rodents and their fleas. This zoonotic cycle is termed sylvatic, campestral, rural, or wild. Plague and can be very complex, involving many rodent and flea species. Worldwide, over 220 species of rodents have been shown to harbor *Y. pestis*. Gerbils are important rodent reservoirs in the Middle East. Some rodents are highly susceptible to infection, resulting in high mortality. Although large numbers of dead and dying rodents are a good indication of an epizootic of plague, rodent species that are resistant to the effects of infection are more important in maintaining the zoonotic cycle. Most cases in military personnel would probably occur as a result of intrusion into the zoonotic cycle during or following an epizootic of plague in wild rodents. Domestic cats and dogs may carry infected rodent fleas into buildings or tents. Cats may occasionally transmit infection by their bites or scratches, or by aerosol when they have pneumonic plague. Troops should not be allowed to adopt cats or dogs as pets during military operations. The entry of wild rodents or their infected fleas into human habitations can initiate an epizootic among commensal rodents, primarily *Rattus* spp., which are highly susceptible to infection. Close association of humans and large populations of infected commensal rodents can result in an urban cycle of plague. A similar cycle can occur in military cantonments harboring large infestations of commensal rodents. The most important vector of urban plague worldwide is the Oriental rat flea, *Xenopsylla cheopis*. Plague is transmitted to humans primarily by the bite of infected fleas. Fleas often exhibit a host preference, but most species of medical importance readily pass from one host to another. A lack of absolute host specificity increases the potential for infection and transmission of pathogens. Plague may also be acquired by handling tissues of infected animals and infected humans, and by person-to-person transmission of pneumonic plague. Crushed infected fleas and flea feces inoculated into skin abrasions or mucous membranes can also cause infection. Not all flea species are competent vectors. The vector competence of the Oriental rat flea is attributed to enzymes produced by the plague bacilli that cause blood to coagulate in the flea's digestive tract. The flea attempts to clear the blockage in its digestive tract by repeated efforts to feed. In the process, plague bacilli are inoculated into the host. Fleas may remain infective for months when temperature and humidity are favorable. *Xenopsylla cheopis* may require 2 to 3 weeks after an infective blood meal before it can transmit plague bacilli.

**IV. Additional Resources:**

CDC Background Plague

WHO Background Plague

Bahmanyar, M. 1972. Human plague episode in the district of Khawlan, Yemen. The American Society of Tropical Medicine and Hygiene. 21 (1): 123-128.

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# Murine Typhus (Flea-borne typhus, Endemic typhus, Shop typhus)

**I. Disease Background:** The infectious agent, *Rickettsia typhi*, causes a milder disease than does *R. prowazekii*, but it still results in a debilitating illness with high fever. The incubation period ranges from 1 to 2 weeks, and clinical symptoms may last up to 2 weeks in untreated cases. Mortality is very low, and serious complications are infrequent. The disease is easily treated with antibiotics. Absence of louse infestation, seasonal distribution, and the sporadic occurrence of murine typhus help to differentiate it from epidemic typhus.

**II. Military Impact and Historical Perspective:** Confusion in diagnosis between murine typhus and closely related diseases may occur. Prior to World War II, murine typhus was not distinguished from the epidemic form, and its importance in prior wars is unknown. During World War II, there were 786 cases in the US Army with 15 deaths. There are little available data on the incidence of murine typhus during military operations in Korea or Vietnam. During the Vietnam War, murine typhus was concentrated in port cities and incidence seemed low. However, retrospective studies indicated that a large proportion of fevers of unknown origin experienced by Americans during that conflict were due to *R. typhi*. The disease is most common in lower socioeconomic classes and increases when disruptions by war or mass migration force people to live in unsanitary conditions in close association with domestic rodents. However, murine typhus has not been a major contributor to disease rates in disaster situations. Because of the sporadic incidence of murine typhus, it is difficult to confidently predict the potential impact of this disease on future military operations, although its military impact would likely be minimal.

**III. Transmission Cycle(s):** Murine typhus is a zoonotic infection associated with domestic rats (*Rattus rattus* and *R. norvegicus*) and vectored by their fleas. The Oriental rat flea, *X. cheopis*, is the most important vector. Neither rodents nor their ectoparasites are affected by infection with *R. typhi*. Murine typhus is transmitted by inoculating crushed fleas or infective flea feces into the skin at the bite site. Scratching due to the irritation of flea bites increases the likelihood of infection. *R. typhi* is rarely transmitted directly by flea bite. Other routes of infection are by inhalation of dry flea feces containing rickettsiae, and ingestion of food contaminated by rodent urine. Dried rickettsiae remain infective for weeks. Murine typhus is not transmitted from person to person.

**IV. Additional Resources:**

CDC Background Murine Typhus

Azad, A.F. 1990. Epidemiology of Murine Typhus. Annual Review of Entomology. 35:553-569.

Petri, W. Jr. 2017. Murine (endemic) typhus. From, Merck Manual: Rickettsial and Related Infections.


Distribution of Murine Typhus in the Middle East (AFPMB, 1999)

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# Onchocerciasis (River Blindness)

**I. Disease Background:** This is a chronic, nonfatal disease in which adult worms form fibrous nodules in subcutaneous tissues. Adult female worms can live for 15 years and produce thousands of microfilariae that migrate through the skin, causing disfiguring skin lesions. Microfilariae invade other tissues and organs and may reach the eye, where their invasion and subsequent death cause visual disturbances and blindness. The parasite is a filarial nematode worm, *Onchocerca volvulus*. A related species, *O. fasciata*, occurs in camels but does not infect humans.

**II. Military Impact and Historical Perspective:** Onchocerciasis has had a devastating impact on villages in the savanna area of West Africa. In many places over 10% of the population is blind. Because of limited exposure, the impact of onchocerciasis would be insignificant during most military operations. The severity of disease depends on cumulative effects of repeated infection that could result in long-term health problems for continuously exposed troops. Knowledge of this could impact troop morale during an operation. Prolonged infection in an endemic area would be required to develop clinically severe disease. After infection, larvae grow into adult worms over a period of months. Microfilariae are found in the skin a year or more after the infective bite, which is usually long after military personnel have left an endemic area.

**III. Transmission Cycle(s):** Man is the definitive host in which O. volvulus multiplies. Microfilariae in human skin are ingested by vector black flies when they suck blood. In the Middle East, vectors are members of the *Simulium damnosum* complex. The microfilariae transform within the black fly to an infective stage that enters the human host when the fly takes subsequent blood meals. This period of development requires 7 to 14 days. Man is also the reservoir host. Onchocerciasis is not considered a zoonosis, although natural infections have been found in a spider monkey in Guatemala and a gorilla in the Congo. Chimpanzees can be infected in the laboratory.

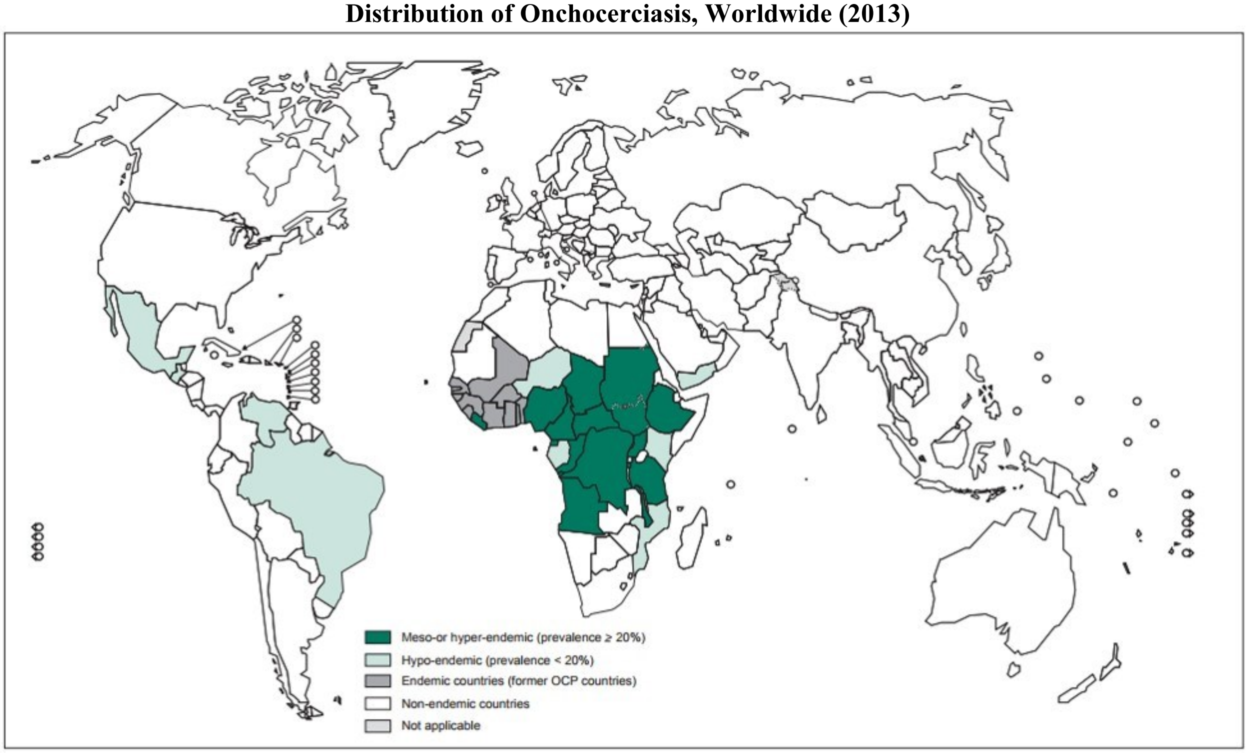
**IV. Additional Resources:**

[CDC Background Onchocerciasis]

[Abdul-Ghaniab, R., Faraga, H.F., Allama, A.F., Shawkyc, S.M. & Al-Mekhlafi, A.M. 2013. Mutant Plasmodium falciparum chloroquine resistance transporter in Hodeidah, Yemen: association with parasitologic indices and treatment-seeking behaviors. Acta Tropica 128: 473-478.]

[Lenoble, R. al Qubati, Y., Toe, L., Pisella, P.J., Gaxotte, P. & al-Kohlani, A. 2001. Human onchocerciasis and "sowda" in the Republic of Yemen. Bulletin de L'Académie Nationale de Médecine, 185(8): 1447-1459.]

**Distribution of Onchocerciasis, Worldwide (2013)**






Data Source: World Health Organization
Map Production: Control of Neglected Tropical Diseases (NTD)
World Health Organization

World Health Organization

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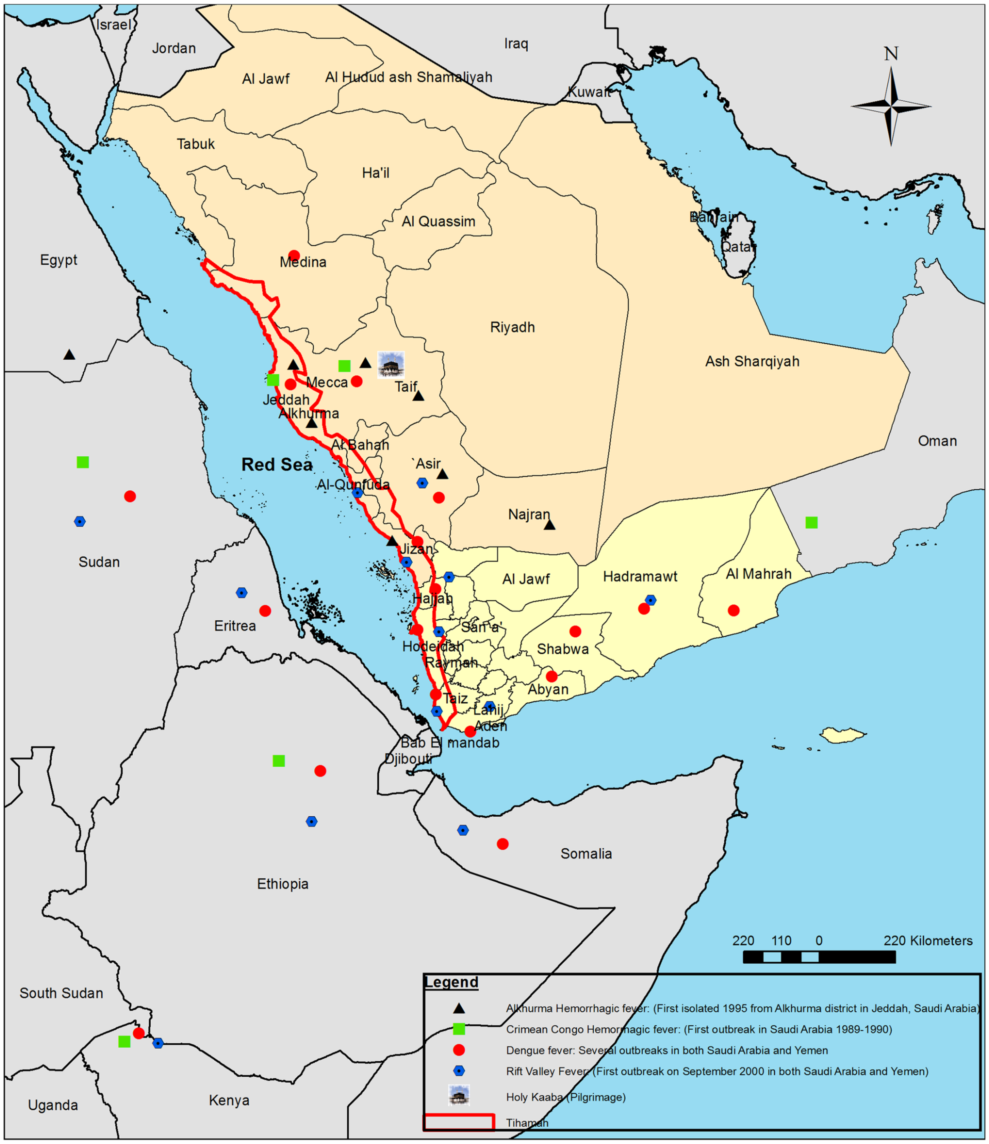
# Viral hemorrhagic fevers in the Tihamah region of the western Arabian Peninsula




**Source:**

Zakham, F., Al-habal, M., Taher, R., Alaoui, A. & El-Mzibri, M. 2017. Viral hemorrhagic fevers in the Tihamah region of the western Arabian Peninsula. PLoS Negl Trop Dis 11(4): e0005322.

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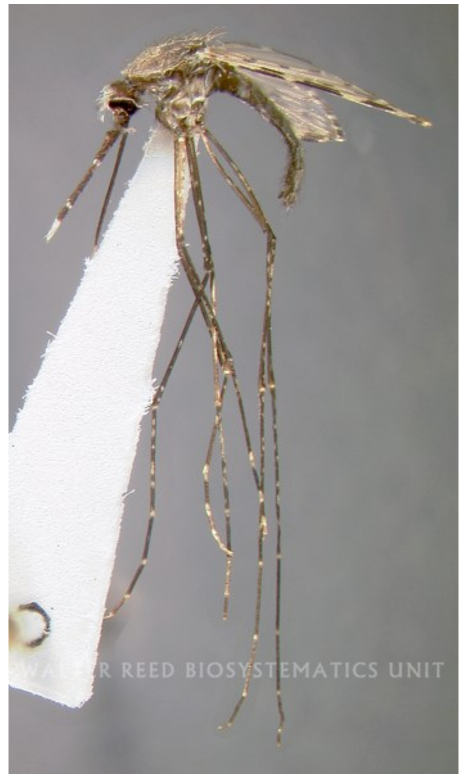
# Mosquito Vector Species Profiles

# *Anopheles* (*Cel.*) *arabiensis* Patton, 1905




## Bionomics:

*An. arabiensis* larvae are found in relative short duration, sunlit water pools (3-5 weeks) with high turbidity and a lack of aquatic vegetation or surface film. Chosen breeding sites appear to be associated with cattle, the preferred host. Although primarily known to occur in dry-savannah type environments, *An. arabiensis* is also found in forested areas that have been recently disturbed or cleared.

Biting and resting behavior of adult female *An. arabiensis* is known to be highly variable. Adults are known to be both anthropophilic and zoophilic depending on the availability of blood meals. This species is also known to modify resting behavior when in contact with some insecticides used during Indoor Residual Spraying (IRS) control measures.

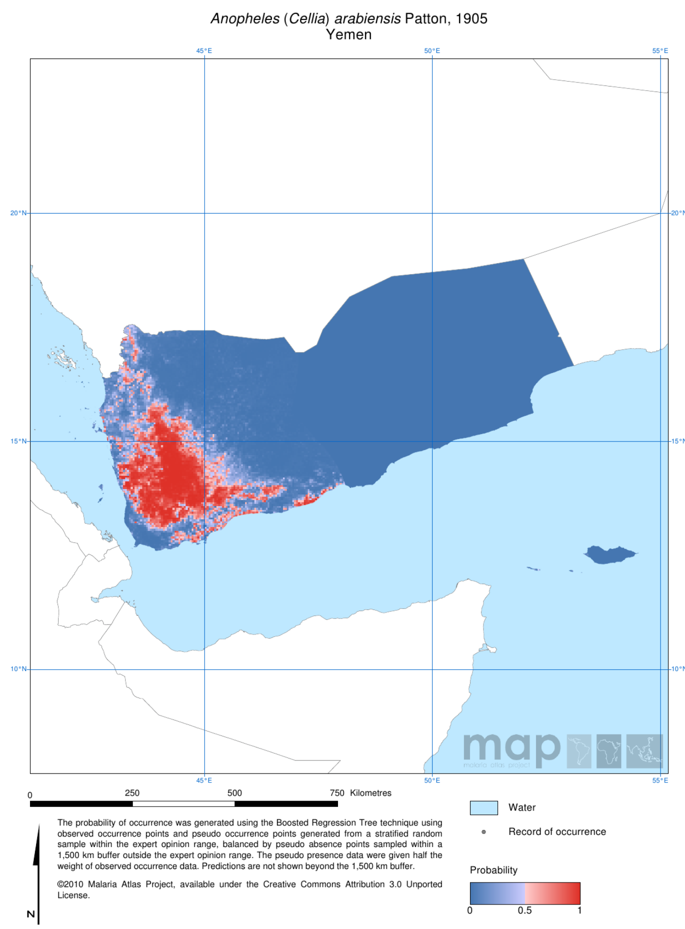
## Medical Importance:

*An. arabiensis* is considered a primary malaria vector in Yemen.

WRBU Catalog

VectorBase

| | |
|---|---|
| **Biting Times:** | 19:00-03:00 |
| **Host Preference:** | Primarily Zoophilic but known to be Anthropophilic on occasion |
| **Feeding Behavior:** | Exophagic |
| **Resting Behavior:** | Primarily Exophillic but known to be Endophillic on occasion |

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# *Anopheles* (*Cel.*) *culicifacies* s.l.


**Note:** The Culicifacies Complex consists of five species informally named species A, B, C, D and E and are nearly morphologically identical. Identification to species level requires molecular barcoding.

## Bionomics:

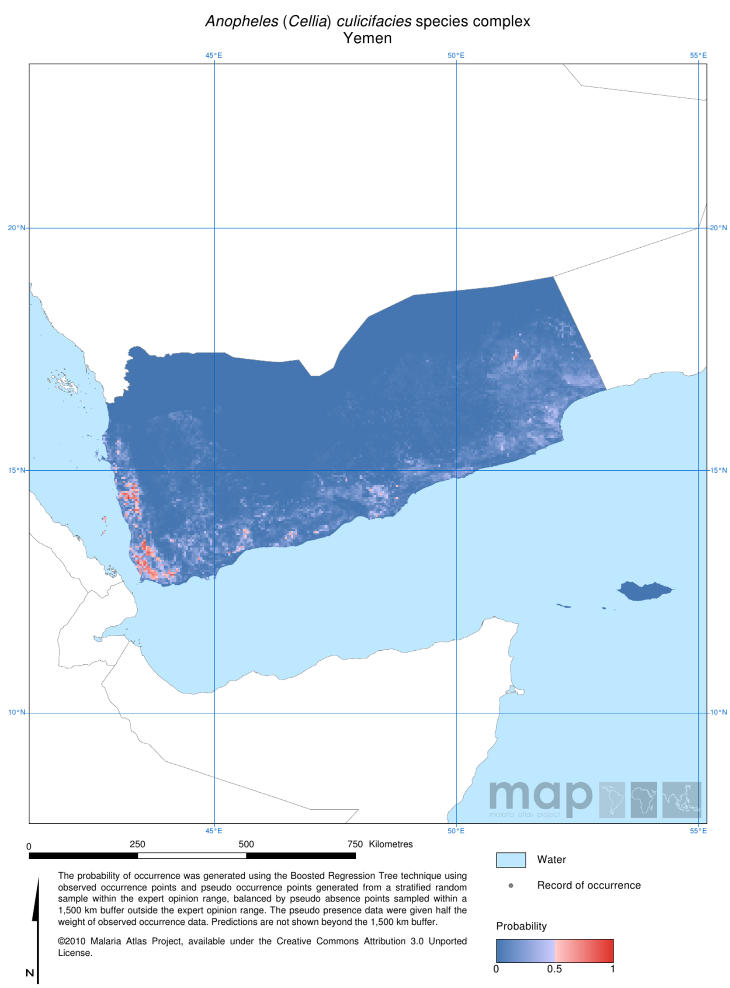
Larvae of *An. culicifacies* s.l. are found in fresh water irrigation ditches, rain pools, pools in riverbeds, freshly dug pits or holes and wells. Females avoid oviposition sites with emergent vegetation. Larvae are typically found between 35 and 960m. Although this species prefers fresh water larval habitats, some evidence indicates that at least some of the species within this complex are tolerant of semi-brackish water.

## Medical Importance:

Species (A, C, D, E) are known malaria vectors, however more research is needed to fully understand the vectorial capacity of all species in the complex. Note: bionomics data will vary from species to species.

WRBU Catalog

VectorBase




| | |
|---|---|
| **Biting Times:** | 23:00-00:00 |
| **Host Preference:** | Primarily Zoophilic but known to be Anthropophilic |
| **Feeding Behavior:** | Endophagic and Exophagic |
| **Resting Behavior:** | Primarily Endophillic but known to be Exophillic |

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# *Anopheles* (*Cel.*) *sergentii* s.l.

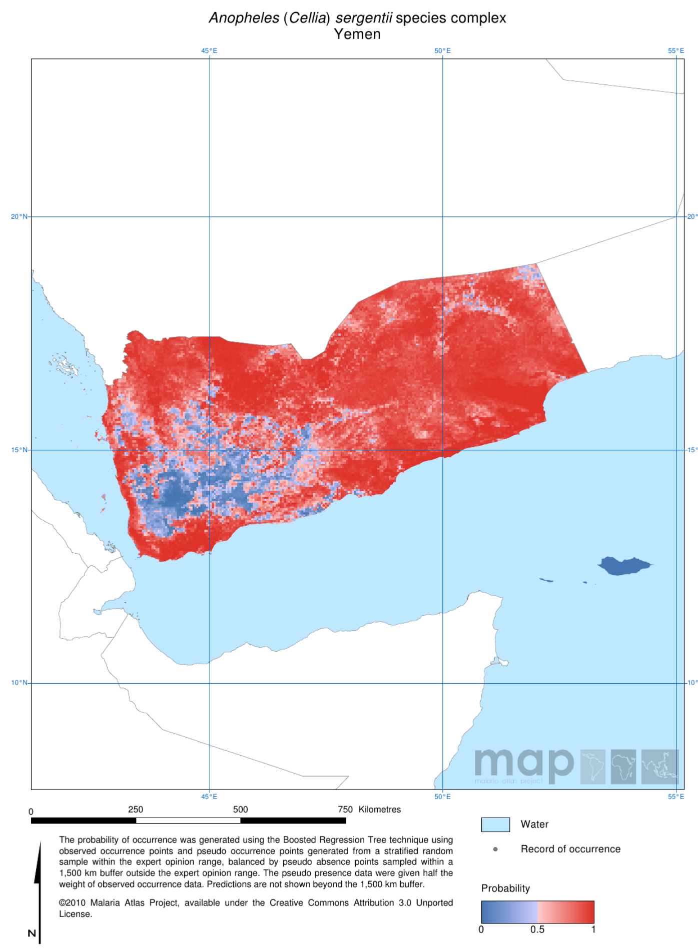

## Bionomics:

*An. sergentii* s.l. larvae occur in oases and irrigated areas in many types of water, shaded and unshaded, with and without vegetation. They are commonly known as the “oasis mosquito” due to it’s association with desert environments across the Sahara to the Middle East. Larval habitats include streams, ditches, irrigation canals and most other non-polluted, shallow sites that contain fresh slow running water with partial shade and emergent vegetation. Some larvae have been found in brackish water.

## Medical Importance:

*An. sergentii* is considered a primary malaria vector of Yemen.

WRBU Catalog




| | |
|---|---|
| **Biting Times:** | Unclear |
| **Host Preference:** | Primarily Zoophilic but known to be Anthropophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Endophillic (natural or man-made) |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# *Anopheles* spp.

**I. 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 using animals, or even humans, as bait are useful for determining feeding preferences of mosquitoes collected (use of humans as bait must be conducted under approved human use protocols). Adults 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. Malaria suppression includes elimination of gametocytes from the blood stream 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 bed nets to prevent mosquito bites, and chemoprophylaxis to prevent infection. 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 control with predaceous fish can control larvae at their aquatic developmental sites before adults emerge and disperse. For more information about Insecticides used for mosquito control consult the AFPMB Technical Guide No. 48, Contingency Pest Management and Vector Surveillance (CAC required). Chemical control may be difficult to achieve in some areas. After decades of malaria control, many vector populations are now resistant to insecticides. Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be used to the extent possible. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects. The interior walls of tents and bunkers can be treated with permethrin to control resting vectors. In Yemen, low-level but increasing drug resistance to Chloroquine has been reported along the coast of the Red Sea and Sanaa.

## II. Reported Insecticide Resistance:

Abdul-Ghaniab, R., Faraga, H.F., Allama, A.F., Shawkyc, S.M. & Al-Mekhlafi, A.M.. 2013. Mutant *Plasmodium falciparum* chloroquine resistance transporter in Hodeidah, Yemen: Association with parasitologic indices and treatment-seeking behaviors. Acta Tropica 128 473-478.

Bamaga, O.A.A., Mahdy, M.A.K. & Lim, Y.A.L. 2014. Malaria in Hadhramout, a southeast province of Yemen: prevalence, risk factors, knowledge, attitude and practices (KAPs). Parasites & Vectors 7:351.

## III. Vector Identification:

Illustrated Key to the Female Anopheles of Southwestern Asia and Egypt (Diptera: Culicidae)

LUCID Pictorial Key to the Medically Important Mosquitoes of CENTCOM

## IV. Additional Resources:

Kouznetsov, R.L. 1976. Distribution of anopheles in the Yemen Arab Republic and its relation to malaria. World Health Organization: Malaria 76.879.

Al-Eryani, S.M.A., Kelly-Hope, L., Harbach, R.E., Briscoe, A.G., Barnish, G., Azazy, A. & McCall, P.J. 2016. Entomological aspects and the role of human behavior in malaria transmission in a highland region of the Republic of Yemen. Malaria Journal, 15:130.

Sinka, M.E., Bangs, M.J, Manguin, S., Chareonviriyaphap, T., Patil, A.P., Temperley, W.H., Gething, P.W., Elyazar, I.R.F., Kabaria, C.W., Harbach, R.E. & Hay, S.I. 2011. The dominant Anopheles vectors of human malaria in the Asia-Pacific region: occurrence data, distribution maps and bionomic précis. Parasites and Vectors. 4: 89

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# *Aedes* (*Stg.*) *aegypti* (Linnaeus, 1762)

## Bionomics:

Primarily found in close association with humans, *Ae. aegypti* will use any and all natural and artificial containers as larval breeding sites. Away from urban areas the species tends to favor pools in river beds, tree stumps, tree holes and natural containers.

## Medical Importance:

*Ae. aegypti* is considered a primary vector of dengue fever, chikungunya and Zika viruses.

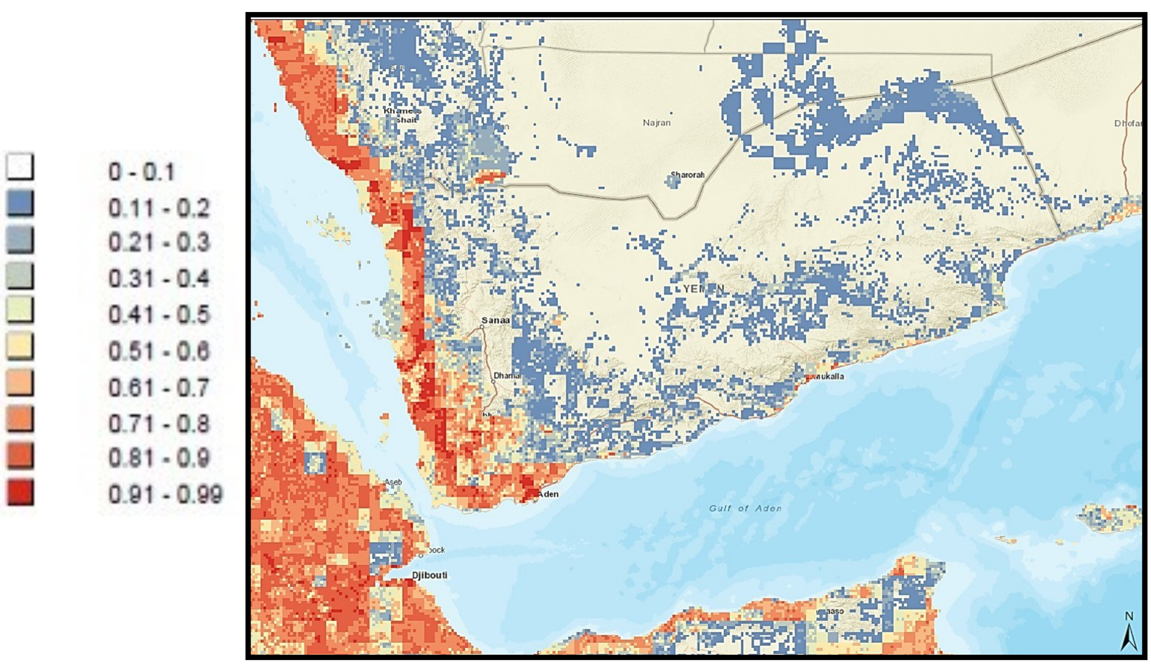
[WRBU Catalog]

[Dengue Vector Bionomics (Ritchie, S. 2014)]

[VectorBase]

| | |
|---|---|
| **Biting Times:** | 06:00-18:00 |
| **Host Preference:** | Primarily Anthropophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Exophilic and Endophillic |


Boosted regression tree model of habitat suitability for *Ae. aegypti*, Global.
Kraemer et al. 2016.

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# *Aedes* (*Stg.*) *aegypti* (Linnaeus, 1762)

**I. 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 one minute, is recorded. Several indices (container, house, Breteau indices) have been devised to provide a relative measure of the larval populations of *Ae. aegypti*. Adult egg-laying activity can be monitored by using black oviposition cups. 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 ultra-low volume (ULV) adulticiding. In some outbreaks of dengue fever, ULV dispersal of insecticides has had only modest impact on adult mosquito populations. *Ae. aegypti* is a domestic mosquito that frequently rests and feeds indoors and therefore is not readily exposed to aerosols. 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. In Singapore, passage of sanitation laws and their strict enforcement to eliminate breeding sites reduced the house index for *Ae. aegypti* larvae from 25% to 1%. Proper disposal of trash, bottles and cans at military cantonments must be rigidly enforced. The individual soldier can best prevent infection by using personal protective measures during the day when *Ae. aegypti* mosquitoes are active. Wear permethrin-impregnated uniforms and use extended-duration DEET repellent on exposed skin surfaces. For more detailed information on control strategies for Aedes aegypti, see the AFPMB Technical Guide No. 47: *Aedes* Mosquito Vector Control.

## II. Reported Insecticide Resistance:

Vontasa, J., Kioulos, E., Pavlidi, N., Morou, E., della Torre, A. & Ranson, H. Insecticide resistance in the major dengue vectors Aedes albopictus and Aedes aegypti. Pesticide Biochemistry and Physiology 104(2): 126-131.

## III. Vector Identification:

Rueda, L.M. 2004. Pictorial keys for the identification of mosquitoes (Diptera: Culicidae) associated with dengue virus transmission. Zootaxa. 589. 1-60.

LUCID Pictorial Key to the Medically Important Mosquitoes of CENTCOM (WRBU)

## IV. Additional Resources:

Aziz, A.T., Al-Shami, S.A., Mahyoub, J.A., Hatabbi, M., Ahmad, A.H. & Rawi, C.S.W. 2014. An update on the incidence of dengue gaining strength in Saudi Arabia and current control approaches for its vector mosquito. Parasites & Vectors, 7:258.

Khaled, G.S., Abdullah A.T., Abdulrahman, A., Alqadsi, A., Enas, Alariqi, F. & Hassaan, F. 2015. Knowledge, attitude and preventive practices regarding dengue fever in rural areas of Yemen. International Health, 7(6): 420–425.

Rezza, G., El-Sawaf, G., Faggioni, G., Vescio, F., Al Ameri, R. & De Santis, R. 2012. Co-circulation of dengue and Chikungunya viruses, Al Hudaydah, Yemen. Emerging Infectious Diseases. 20(8): 1351-1354.

Zakham, F., Al-habal, M., Taher, R. Alaoui, A., El Mzibri, M. 2017. Viral hemorrhagic fevers in the Tihamah region of the Western Arabian peninsula. PLoS Neglected Tropical Diseases. 11(4): e0005322.

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# *Aedes* (*Adm.*) *vexans* (Meigen, 1830)


## Bionomics:

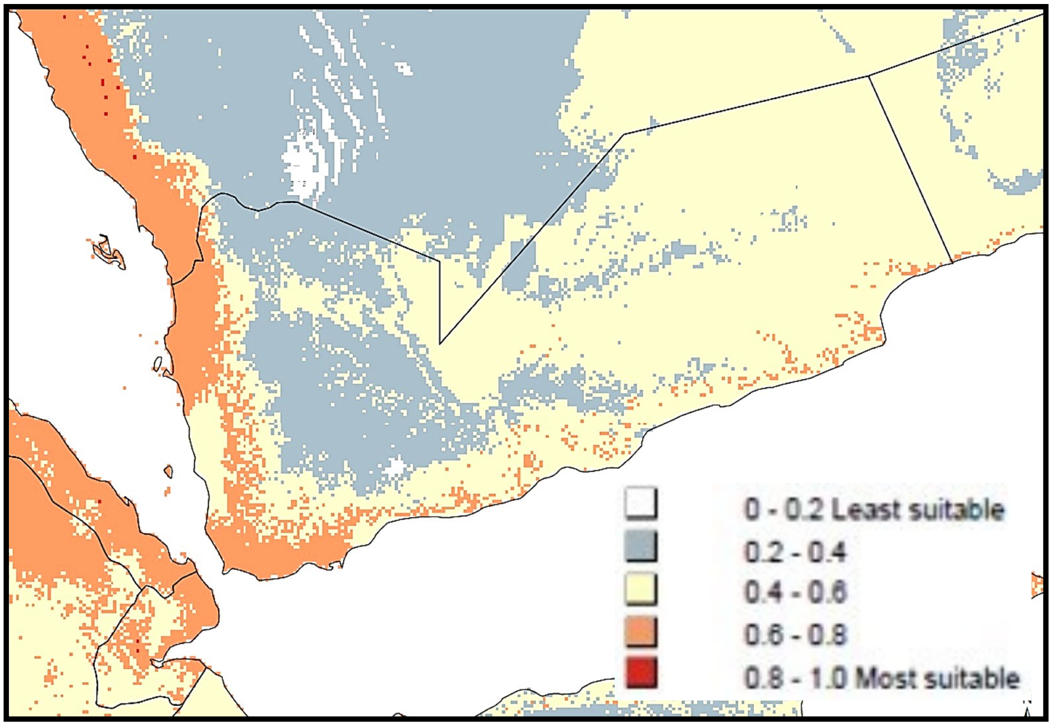
Immatures of *Ae. vexans* are found in unshaded fresh water flood pools in secondary scrub, but have also been collected in ditches, swamps and rice fields. Habitats usually have little aquatic vegetation or algae. Females are night biters and readily feed on man and cattle (Reinert 1973).

## Medical Importance:

*Ae. vexans* is capable of transmitting West Nile Virus (Turell et al. 2005)

WRBU Catalog

Maximum entropy habitat suitability model for *Aedes vexans* (Nyari, 2011)

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# *Culex* (*Cux.*) *pipiens* Linnaeus, 1758

## Bionomics:

Larvae of *Cx. pipiens* are found in numerous and variable breeding places ranging from highly polluted cesspits to clear water pools and containers. Both shaded and unshaded larval habitats are utilized by this species. Although fresh water seems to be this species preference, it will lay eggs in moderately brackish water as well. *Cx. pipiens* usually breeds in stagnant water in either shaded or unshaded situations. Females readily feed on humans both indoors and outdoors.

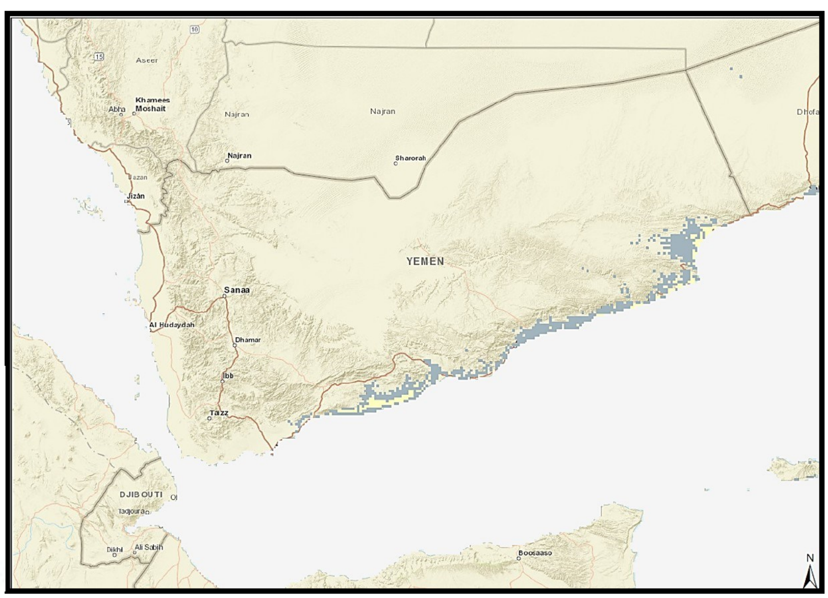

## Medical Importance:

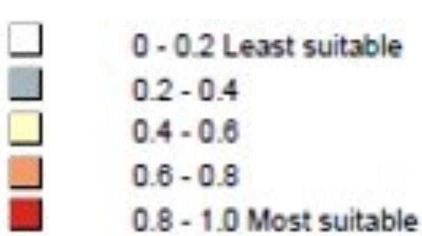
Adult *Cx. pipiens* have been found naturally infected with Sindbis virus and West Nile viruses in Israel, West Nile and Rift Valley Fever in Egypt, and is a primary vector of periodic Bancroftian filariasis.

[WRBU Catalog]

| | |
|---|---|
| **Biting Times:** | 18:00-06:00 |
| **Host Preference:** | Anthropophilic and Zoophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Exophilic and Endophillic |

Maximum entropy habtat suitability model for *Culex pipiens* (Dornak, 2011)

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# *Culex* (*Cux.*) *univittatus* Theobald, 1901

## Bionomics:

Larvae of *Cx. univittatus* are found in ground pools, marshy pools, barrow pits, stagnant drains and streams, canals and shallow wells. Females feed primarily on birds and mammals but will opportunistically feed on humans.

## Medical Importance:

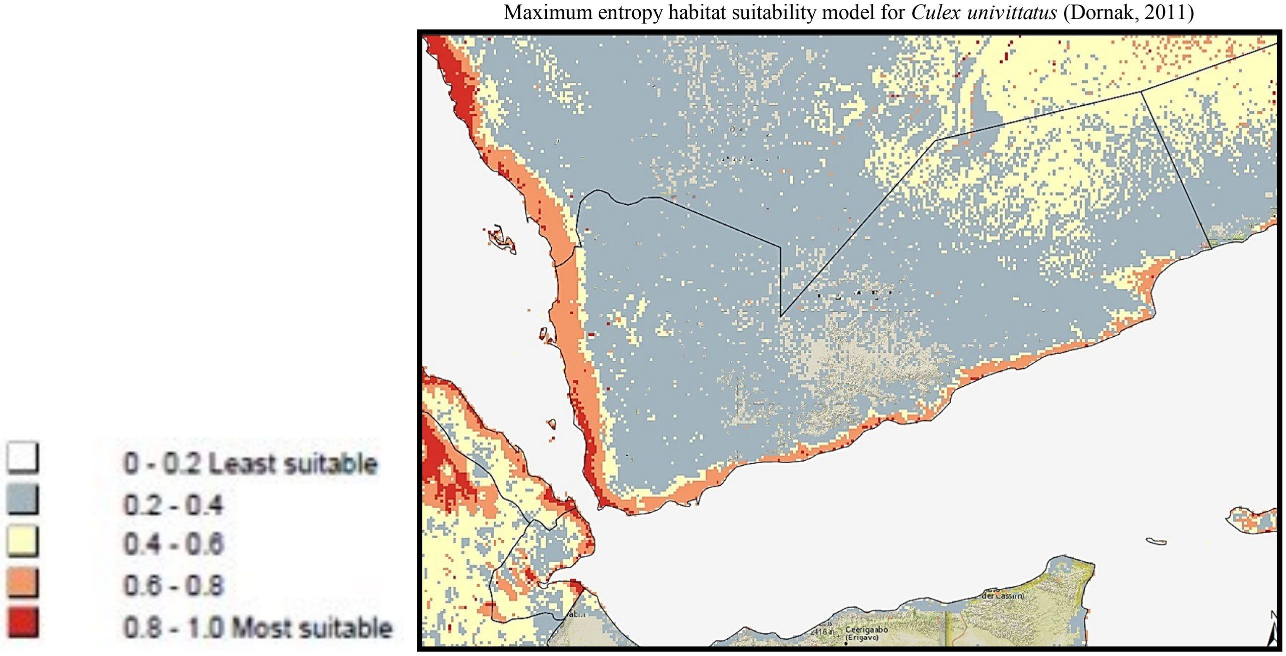
*Cx. univittatus* are known to vector West Nile and Sindbis virus in Yemen.

[WRBU Catalog]

[Distribution and bionomics of Egyptian *Culex univittatus* (Theobald)]

| | |
|---|---|
| **Biting Times:** | 18:00-06:00 |
| **Host Preference:** | Anthropophilic and Zoophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Exophilic and Endophillic |

Maximum entropy habitat suitability model for *Culex univittatus* (Dornak, 2011)

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# *Culex* (*Cux.*) *quinquefasciatus* Say, 1823


### Bionomics:

Larvae of *Cx. quinquefasciatus* can be found in bodies of water containing a high degree of organic pollution. Open drains and domestic water storage containers are often utilized by this species and are often found in and around urban environments.

### Medical Importance:

*Cx. quinquefasciatus* is a known vector of West Nile Virus (WNV) and Rift Valley Fever Virus (RVFV).

WRBU Catalog

Profile: *Culex quinquefasciatus*

| | |
|---|---|
| **Biting Times:** | 18:00-06:00 |
| **Host Preference:** | Primarily Anthropophilic and Zoophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Exophilic and Endophillic |

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# *Culex* (*Ocu.*) *bitaeniorhynchus* Giles, 1901


### Bionomics:

Larvae of *Cx. bitaeniorhynchus* are restricted to ground water habitats containing filamentous green algae (*Spirogyra*).

### Medical Importance:

Adult *Cx. bitaeniorhynchus* have been found naturally infected with *W. bancrofti* and is considered a potential vector of Sindbis virus.

WRBU Catalog

| | |
|---|---|
| **Biting Times:** | 18:00-06:00 |
| **Host Preference:** | Anthropophilic and Zoophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Exophilic and Endophillic |

# *Culex* spp.

**I. Vector Surveillance and Suppression:** Reduction of mosquito populations by ultra-low volume (ULV) spraying may be useful as a means of disease control. The most feasible long-term control strategies involve reducing vector breeding by environmental management techniques. Personal protective measures to prevent mosquito bites are the most practical means of avoiding infection with WNV and Sindbis virus. Consult AFPMB Technical Guide No. 13: Dispersal of Ultra Low Volume (ULV) Insecticides by Cold Aerosol and Thermal Fog Ground Application Equipment; AFPMB Technical Guide No. 24: Contingency Pest Management Guide, and AFPMB Technical Guide No. 40: Methods for Trapping and Sampling Small Mammals for Virologic Testing.

## II. Reported Insecticide Resistance:

Ali, S.A. 2010. Insecticide resistance of Culex pipiens (L.) populations (Diptera: Culicidae) from Riyadh city, Saudi Arabia: Status and overcome. Saudi Journal of Biological Sciences. 17(2): 95-100.

Norris, L.C. & Norris, D.E. 2011. Insecticide resistance in *Culex quinquefasciatus* mosquitoes after the introduction of insecticide-treated bed nets in Macha, Zambia. Journal of Vector Ecology. 36(2): 411-420.

Osta, M.A., Zeinab, J.R., Labbé, P., Weill, M & Knio, K. 2012. Insecticide resistance to organophosphates in *Culex pipiens* complex from Lebanon. Parasites and Vectors 5:132.

## III. Vector Identification:

Harbach, R.E. 1985. Pictorial keys to the genera of mosquitoes, subgenera of Culex and the species of Culex (Culex) occurring in southwest Asia and Egypt, with a note on the subgeneric placement of Culex deserticola (Diptera: Culicidae). Mosquito Systematics. 17: 83-107.
LUCID Pictorial Key to the Medically Important Mosquitoes of CENTCOM (WRBU)

## IV. Additional Resources:

CABI, 2017. *Culex quinquefasciatus* (southern house mosquito). In: Invasive Species Compendium. Wallingford, UK: CAB International. https://www.cabi.org/isc/datasheet/86848

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# *Aedes* (*Och.*) *caspius* (Pallas, 1771)


## Bionomics:

Immature *Ae. caspius* utilize shallow brackish pools with little or no shade and are usually associated with irrigation runoff. Adult females are day-time biters with a preference for sheep and humans (Kenawy, 1987).

## Medical Importance:

A known vector of Rift Valley Fever virus (RVFV) and West Nile Virus in Yemen.

WRBU Catalog

## Vector Surveillance and Suppression: 

See Vector Surveillance and Suppression for *Aedes* spp.

## Vector Identification:

Harbach, R.E. 1985. Pictorial keys to the genera of mosquitoes, subgenera of Culex and the species of Culex (Culex) occurring in southwest Asia and Egypt, with a note on the subgeneric placement of Culex deserticola (Diptera: Culicidae). Mosquito Systematics. 17: 83-107.

LUCID Pictorial Key to the Medically Important Mosquitoes of CENTCOM (WRBU)

| | |
|---|---|
| **Biting Times:** | 06:00-18:00 |
| **Host Preference:** | Anthropophilic and Zoophilic |
| **Feeding Behavior:** | Exophagic and Endophagic |
| **Resting Behavior:** | Exophilic and Endophillic |

## Additional Resources:

Harbach, R.E. 1988. The mosquitoes of the subgenus *Culex* in Southwestern Asia and Egypt (Diptera: Culicidae). Contributions to the American Entomological Institution 24(1): 1-240.

Kenawy M.A., Beier J.C., Zimmerman J.H., El Said S., Abbassy M. M., 1987. Host-feeding patterns of the mosquito community (Diptera: Culicidae) in Aswan Governorate, Egypt . Journal of Medical Entomology. 24 : 35-39.

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# Sand Fly Vector Species Profiles

# Sand Flies of Yemen

**I. General Information:** Adult sand flies rest during the daytime in dark, humid, protected areas, such as rodent burrows, rock crevices and caves. The preparation of military bunkered ground positions in desert areas provides additional protected daytime resting sites for phlebotomine sand flies. In urban areas, sand fly adults often rest in dark, cool, humid corners of inhabited human and animal structures. Abandoned structures and their vegetative overgrowth often become attractive wild rodent habitats and foci of rural CL. Vegetation is important as a sugar source for both male and female sand flies. Sugar is required for females developing parasite infections. Eggs are developed after a blood meal and are deposited in dark, humid, protected areas. They develop into minute caterpillar-like larvae that feed on mold spores and organic debris. The larvae go through four instars and then pupate near larval feeding sites. Development from egg to adult is 30 to 45 days, depending on feeding conditions and environmental temperatures. Phlebotomine sand fly eggs, larvae and pupae have seldom been found in nature, although exhaustive studies and searches have been made. The adult female has been observed to spread eggs around rather than ovipositing in single egg laying sites. The larvae are believed to be widely distributed in endemic environments but are probably below the ground surface in termite mounds, rodent burrows or other tunnels where temperature, humidity and mold growth provide ideal growing conditions. Because of their minute and delicate nature, larvae have seldom been collected in the wild. The dusk to dawn movement of adults is characterized by flight just above the ground surface to avoid wind. Adult sand flies generally do not travel great distances, and most flights are believed to be less than 100 meters. The females fly in a low hopping flight just above the ground in search of rodent hosts. Both male and female sand flies seek plant sugars from local vegetation. Sand fly habitats in the Middle East region range in altitude from desert areas below sea level to 2,800 m in the mountains. Where seasonal temperature and rainfall changes occur, large numbers of adult sand flies are common in the warmer months of April through October, especially after rains. However, *Le. tropica* peak seasonal incidence occurs during January and February. Vector sand flies have short flight ranges. Their dusk to dawn flights coincide with the nomadic activity of peoples of the region, who often travel at night to avoid the extreme heat of daytime hours. Areas with some vegetation, and cliffs, rock outcroppings, or other geologic formations that allow for suitable hiding places and daytime resting sites are important habitats. Exact information on reservoirs and vectors will require more extensive study in many countries of the region. Vast areas of these countries remain unsurveyed for vectors and disease. When searches are made, sand fly vectors are often found in areas where they were previously unknown.

**II. Vector Surveillance and Suppression:** Sand flies may be collected by a variety of methods. Light traps used for mosquito collection should be modified with fine mesh screens because the small size of phlebotomine sand flies allows them to pass through normal mosquito netting. Sticky traps prepared with paper and vegetable or plant oil are useful and may be placed near rodent burrows, rock crevices, building debris, in and around buildings or constructed military earthworks, and in local vegetation where sand flies are likely to rest during daytime hours. The sticky paper trap is also useful where light traps are either unavailable or their use is limited due to night security measures. Aspirator collections by trained personnel from sand fly resting sites are useful but labor intensive. Identification requires a microscope and some training; however, with some experience, sorting and identification by color and size is quite accurate using minimal magnification. For proper species identification, laboratory microscopes having 100X magnification are required or molecular barcoding. Sand flies are susceptible to most pesticides, and residual insecticide spraying of grounds/structures (inside and outside walls) of encampment areas, coupled with barrier spraying of 200 m of territory surrounding encampment sites, is effective. When the use of organophosphates or other insecticides is impractical due to the combat situation or other operational requirements, personal protective measures (proper wearing of permethrin-treated uniforms and skin repellents) will provide nearly complete protection. Normal mosquito bed nets and screening are ineffective because of the ability of sand flies to crawl through the mesh. Commanders must inform troops of the risks of infection and monitor the proper wearing of uniforms and use of skin repellents. Since small desert rodents are often the normal hosts of sand flies, selection of encampment sites without vegetation or rock outcroppings that enhance rodent harborage is important. Cleanup and removal of garbage and debris that encourage rodent harborage are necessary for longer periods of occupation. Where combat situations outweigh selection and cleanup, residual insecticide spraying will greatly reduce sand fly prevalence. Again, proper wearing of treated uniforms and use of skin repellents will suffice where other control measures cannot be used to reduce sand fly incidence. Pets must be strictly prohibited because any small desert rodent and/or local dog may be infected with cutaneous or visceral leishmaniasis and other infectious diseases. For more information on control strategies for sand flies consult the AFPMB Technical Guide No. 49: Sand Flies (Diptera: Psychodidae: Phlebotominae): Significance, Surveillance, and Control in Contingency Operations.

## III. Vector Identification:

LUCID Pictorial Key to the Medically Important Mosquitoes of CENTCOM (WRBU)

## IV. Additional Resources:

Bahira M., Sawaf, E., Kassem, H.A., Mogalli, N.M., El Hossary, S.S. & Ramadan, S.F. 2016. Current knowledge of sand fly fauna (Diptera: Psychodidae) of northwestern Yemen and how it relates to leishmaniasis transmission. Acta Tropica. 162: 11-19.

Claborn, D.M. 2010. The biology and control of leishmaniasis vectors. Journal of Global Infectious Diseases. 2(2): 127-134.

Daoud, W., Rioux, J.A., Delalbre-Belmonte, A., Dereure, J. & Rageh, H.A. 1989. Eco-epidemiology of visceral and cutaneous leishmaniasis in the Arab Republic of Yemen. III. Inventory and dynamics of Phlebotomus. Bulletin de la Société de Pathologie Exotique. 82(5): 669-677.

Reem, A.A., Tahany, H.A., Mashael, A. & Ahmed, A.A.. 2015. Molecular and morphological identification of local sand fly species (Diptera: Psychodidae) in Saudi Arabia. Pakistan Journal of Zoology. 47(6): 1625-1630.

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# *Phlebotomus* (*Phl.*) *papatasi* (Scopoli, 1786 )

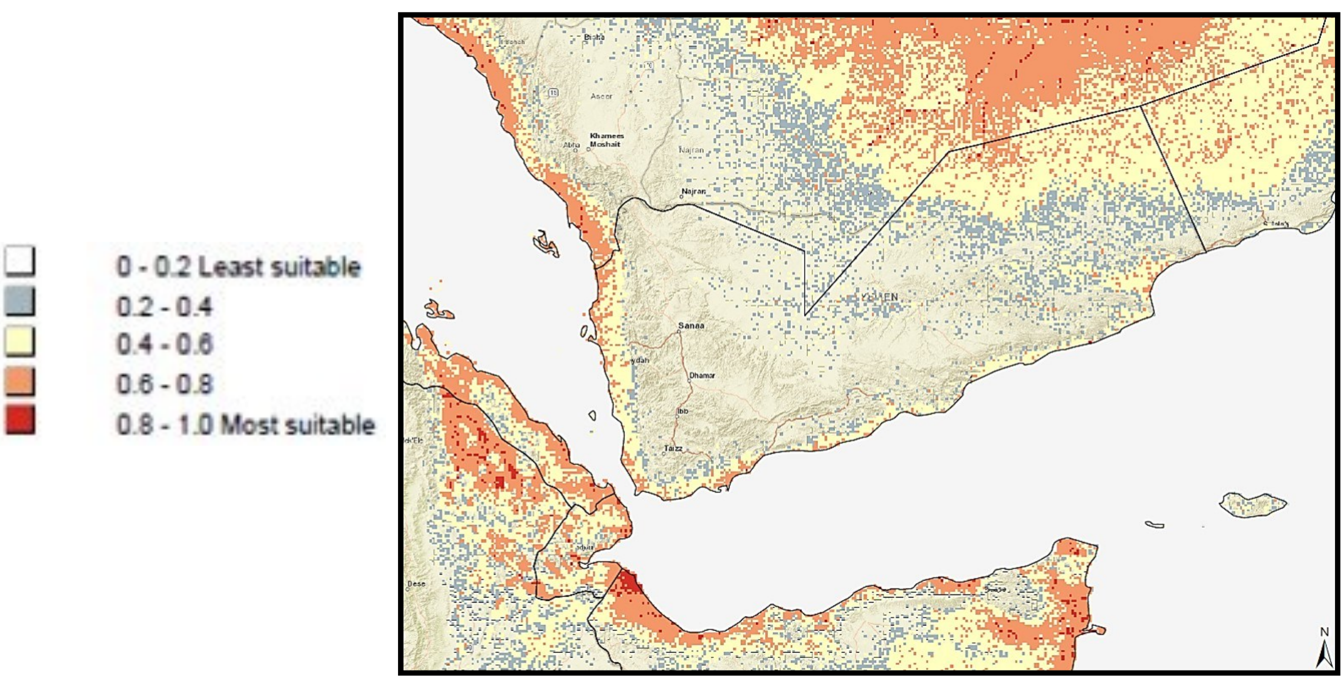

**Bionomics:** *Ph. papatasi* is often domestic, anthropophilic and abundant in (small) rodent burrows. Not much is known about natural breeding sites however the type locality for this species is broadleaf forest.

**Medical Importance:** *Ph. papatasi* is a proven vector of *L. major* to humans and gerbils in U.S.S.R., Saudi Arabia, southern Morocco and central Tunisia (Killick-Kendrick, 1990; Killlck-Kendrick et al., 1985; Lane & Fritz, 1986; Perfil'ev, 1966). Of several Phlebovirus serotypes isolated from *P. papatasi* (in north Africa, southern Europe, Iran and central Asia), Naples and Sicilian were found infecting man only where this sand fly occurs (Tesh, 1988; Tesh et al., 1976).

[WRBU Catalog]

[VectorBase]

Maximum entropy habitat suitability model for *Phlebotomus papatasi* (Dornak, 2011)

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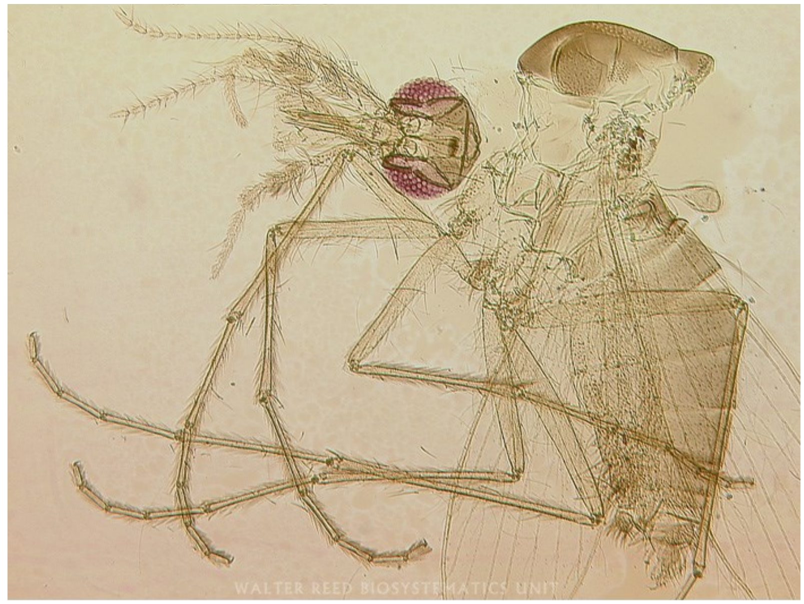
# *Phlebotomus* (*Pab.*) *alexandri* (Sinton, 1928)

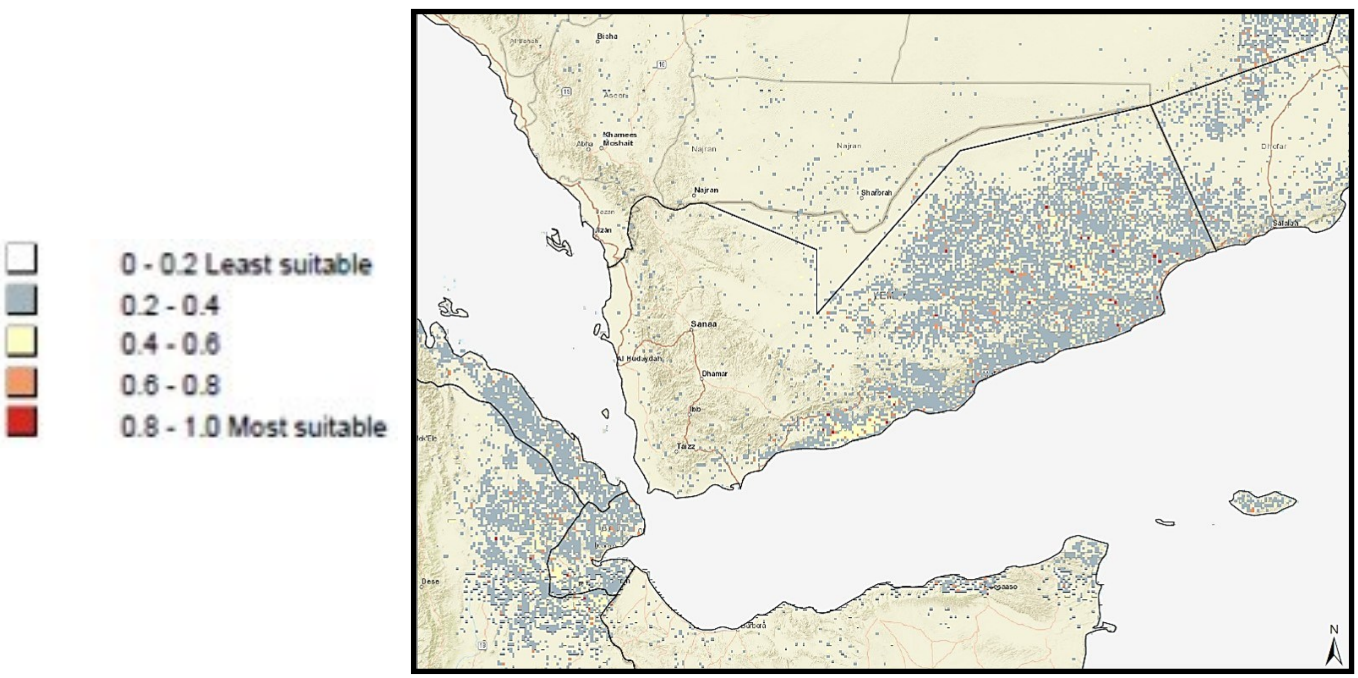



**Bionomics:** The type habitat of *Ph. alexandri* is steppe and the species is considered anthropophilic (Artemiev, 1978a).

**Medical Importance:** Proven vector of visceral leishmaniasis (*L. donovani*) in China (Killick-Kendrick, 1990; Lengo 1988); suspected vector of cutaneous leishmaniasis (*L. major*) in Iran (Javadian *et al.*, 1977), Mongolia and Turkmenistan (Dedet, 1979; Killick-Kendrick, 1990); and suspected vector of *L. tropica killicki* in Tunisia (Croset *et al.*, 1978; Killick-Kendrick, 1990).

[WRBU Catalog]

Maximum entropy habitat suitability model for *Phlebotomus alexandri* (Dornak, 2011)

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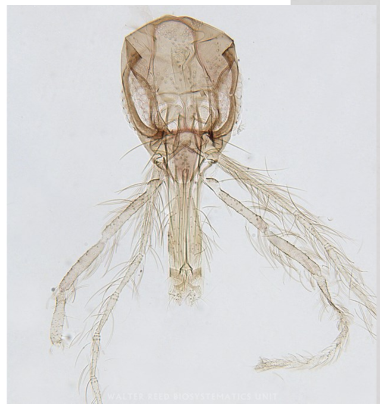
# *Phlebotomus* (*Lar.*) *orientalis* (Parrot, 1936)

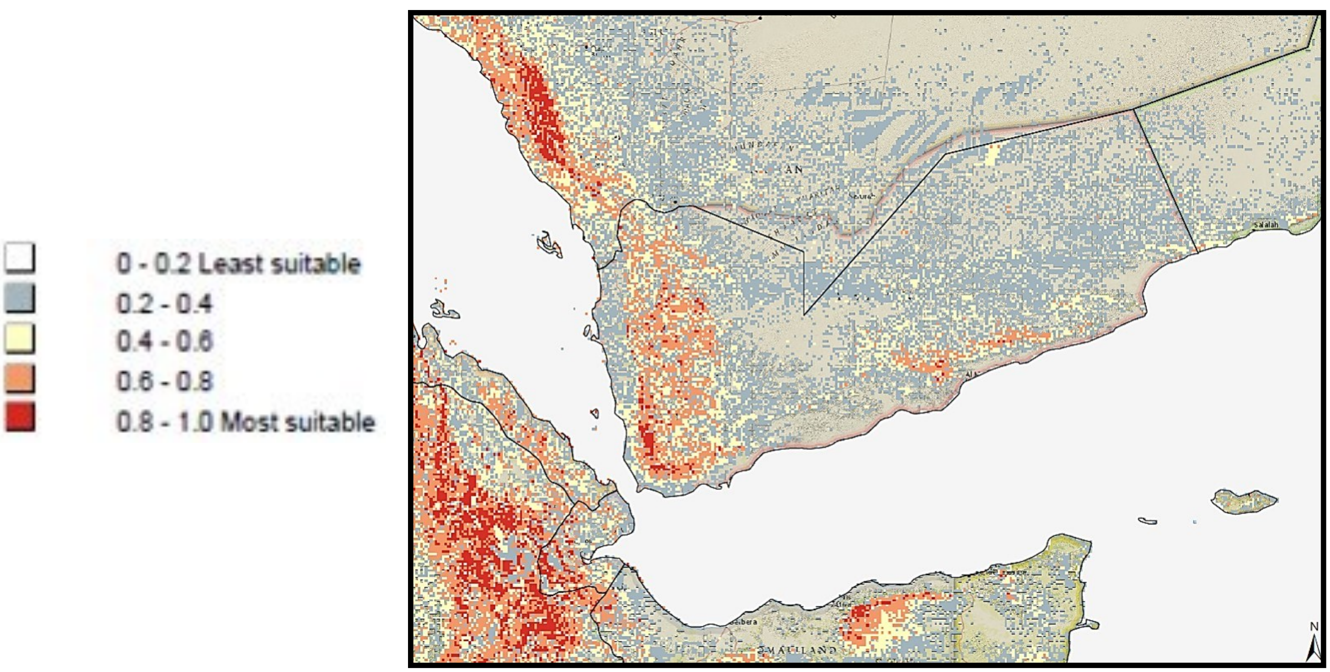
**Bionomics:** The type habitat of *Ph. orientalis* is prairie/mountain vegetation.



**Medical Importance:** *Ph. orientalis* is a known vector of *L. donovani* (or *L. archibaldi*) and main human-biter in the Acacia-Balonites forests of Sudan (Hoogstraal & Heyneman, 1969; Killick-Kendrick, 1990) [Seccombe & Ready 1993: 11].

[WRBU Catalog]

Maximum entropy habitat suitability model for *Phlebotomus orientalis* (Dornak, 2011)

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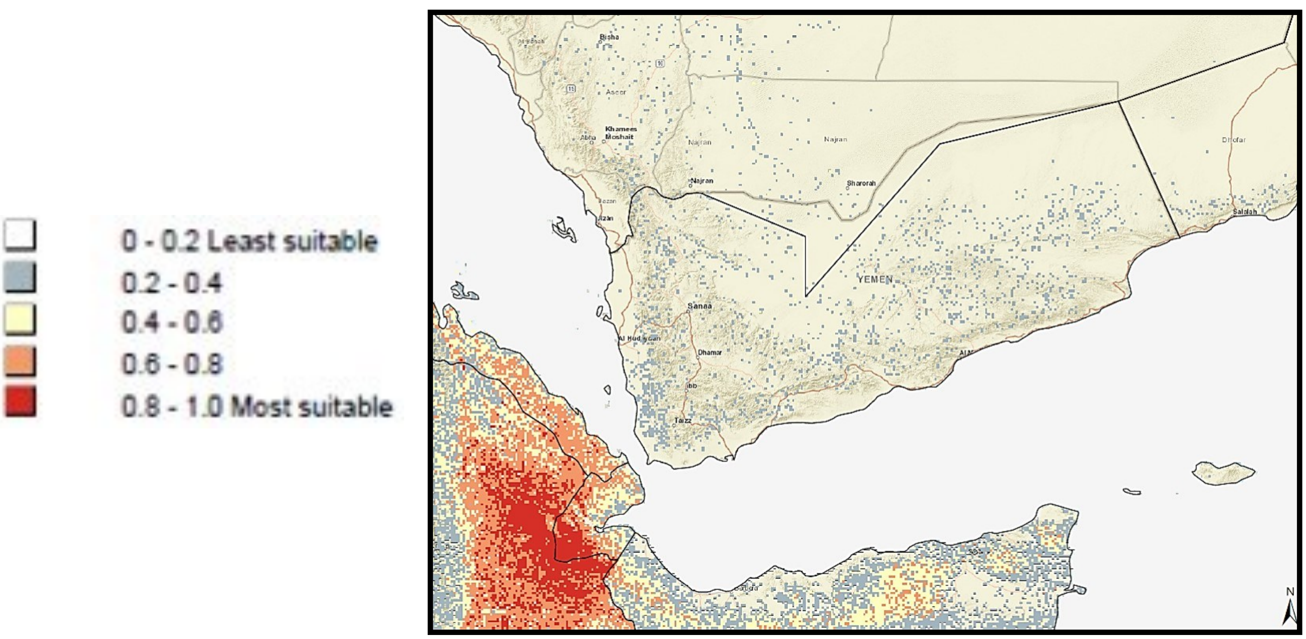
# *Phlebotomus* (*Phb.*) *bergeroti* (Parrot, 1934)

**Bionomics:** The type habitat of *Ph. bergeroti* is desert vegetation. This species is xerophilic and anthropophillc.

**Medical Importance:** *Ph. bergeroti* is a suspected vector of cutaneous leishmaniasis (*L. major*) in the Sahara region (Artemiev, 1978a) and of sand fly fever in Ethiopia (Abonnenc, 1972) based on its close relationship to *Ph. papatasi*.

WRBU Catalog

Maximum entropy habitat suitability model for *Phlebotomus bergeroti* (Dornak, 2011)

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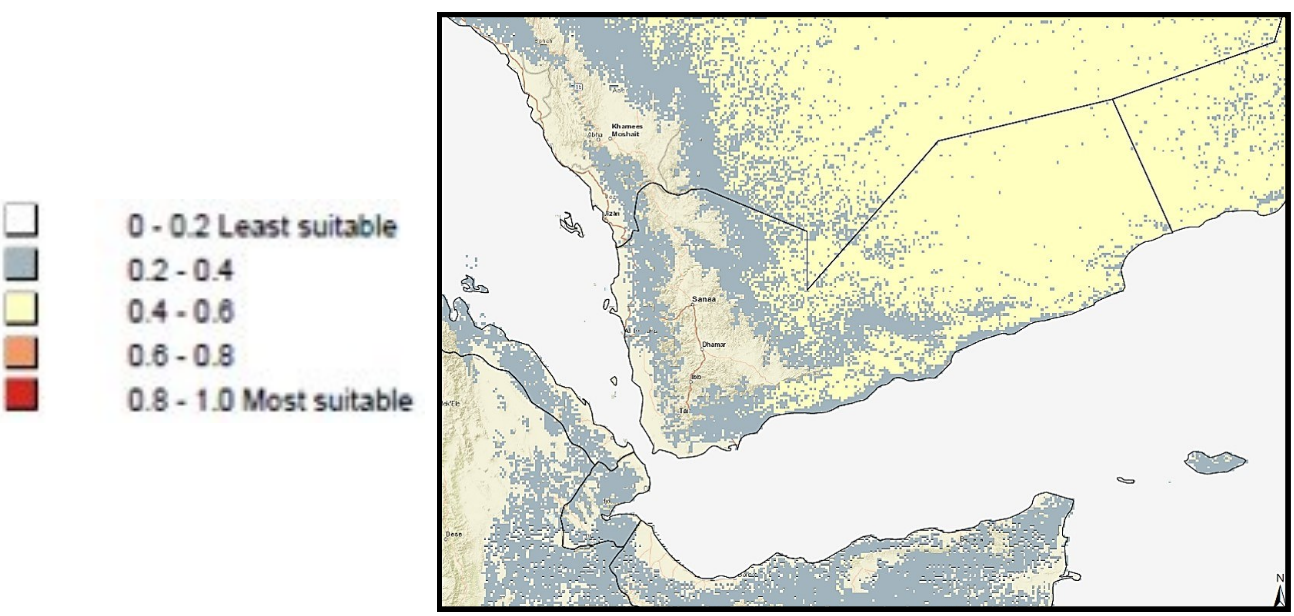
# *Phlebotomus* (*Pab.*) *sergenti* (Parrot, 1917)

**Bionomics:** *Ph. sergenti* is often domestic, anthropophilic and abundant in (small) rodent burrows. Not much is known about natural breeding sites however the type locality for this species is broadleaf forest. This species range extends further north than *Ph. papatasi*.

**Medical Importance:** *Ph. sergenti* is considered a vector of *L. tropica* in Afghanistan, Crete, Iran, Iraq and India on the basis of distribution and ecology (Adler & Theodor, 1957; Lewis & Ward, 1987).

WRBU Catalog

Maximum entropy habitat suitability model for *Phlebotomus sergenti* (Dornak, 2011)

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# Tick Vector Species Profiles

# Argasid (soft) ticks

# Ixodidae (hard) ticks

# Argasid (soft) ticks

## *Ornithodoros savignyi*

**Bionomics:** Ornithodoros species inhabit sheltered areas, such as caves, stables, and rock outcroppings. *Ornithodoros savignyi* is frequently encountered along trails or in the shelter of trees at oases. It feeds on camels and goats but may feed on humans. Nymphs and adults feed quickly and usually painlessly, so their bites may go undetected by the human host until well after the tick has detached. Depending on species, larvae may be quiescent and non-feeding or may attach to a host for several days. Subsequent nymphal stages are active and feed on blood. Engorgement is rapid, and these ticks drop off their hosts after feeding. After 2 to 8 molts (generally 3 to 4), adults emerge and mate. The female mates after feeding and then begins to lay eggs. Females may live many years without a bloodmeal, but blood is required for egg development. The number of eggs deposited may total several hundred over the life span of the female, with up to 8 batches of eggs produced.

**Medical Importance:** *Ornithodoros* species are known vectors of Tick-borne relapsing fever.

### Vector Identification:

Abdel-Shafy, S., Gabr, H.S., Abdullah, H.H., Mahmoud, M.S. 2016. Morphological and molecular description of immature stages of *Ornithodoros savignyi* (Acari: Argasidae). Parasitology Research. 115(8): 3033-3040.

Hoogstraal, H. 1981. Ticks (Acarina) of Saudi Arabia. Fam. Argasidae, Ixodidae. Fauna of Saudi Arabia , 3 , p. 25.

**Vector Surveillance and Suppression:** Argasid ticks such as *Ornithodoros* sp. are found in the restricted habitats of their hosts and rarely move very far. They can be found in loose, dried soil of dwellings, cracks and crevices in mud-walled animal shelters, animal burrows and animal resting places, and under 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. Ornithodorine ticks fluoresce brightly under ultraviolet light. There is little seasonal fluctuation in numbers of argasids since their microhabitats are relatively stable. Tents and bedding can be treated with the repellent permethrin to protect against tick bites. Encampments should not be established in areas infested with *Ornithodoros* ticks. Troops should avoid using indigenous shelters, caves, or old bunkers 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 soft ticks 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.

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# Ixodidae (hard) ticks

**Bionomics (General):** Vector ticks, and hence the disease, tend to be more urban than rural in distribution because they are associated with hosts found in urban areas. The brown dog tick, in particular, tends to be more concentrated in urban areas, where its canine hosts are abundant. In the Asir District of Saudi Arabia, and in Yemen, vector ticks are active year-round. After feeding, females drop from the host and oviposit.

## Vector Identification:

Hyalomma anatolicum excavatum. Bristol University Tick ID, An Online Photographic Guide to Ticks.

Abdullah, H.H. 2016. Morphological and molecular identification of the brown dog tick *Rhipicephalus sanguineus* and the camel tick *Hyalomma dromedarii* (Acari: Ixodidae) vectors of Rickettsioses in Egypt. Veterinary World. (10): 1087-1112.

Hoogstraal, H. & Kaiser, M.N. 1958. The Ticks (Ixodidae) of Iraq: keys, hosts and distribution. Journal of the Iraqi Medical Professions. 6(2/3): 1-22.

**Medical Importance:** *Hyalomma rufipes*, *H. anatolicum anatolicum*, *H. anatolicum excavatum*, *H. truncatum*, and *H. marginatum* s.l. are considered the primary tick vectors of CCHF. Their importance depends heavily on host preference. *Hyalomma dromedarii* and *H. impeltatum* are primarily enzootic vectors. *Boophilus annulatus* and *Rhipicephalus sanguineus*, the brown dog tick, are suspected zoonotic vectors of CCHF and will feed on humans whenever close associations occur. Enzootic infection in dogs, rodents and other animals is usually subclinical. Transmission to humans is by bite of infected ticks. Contamination of breaks in the skin or mucous membranes with crushed tissues or feces of infected ticks can also lead to infection. Several species of Ixodid ticks transmit *C. burnetii* to animals but are not an important source of human infection.

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# Ixodidae (hard) ticks

*Amblyomma variegatum* Photo credit AFPMB

*Amblyomma variegatum* Fabricius 1794
AFPMB, 2017

| | |
|---|---|
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Sheep and cattle, and occasionally humans. |


*Hyalomma dromedarii* Photo credit AFPMB

*Hyalomma dromedarii* Koch, 1844
AFPMB, 2017

| | |
|---|---|
| Bionomics | This species may be either a two- or three-host tick. |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Camels, cattle, goats, dogs, small mammals, lizards and occasionally humans |
| Oviposition | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |

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# Ixodidae (hard) ticks


*Hyalomma truncatum* Photo credit AFPMB

*Hyalomma truncatum* Koch, 1844
AFPMB, 2017

| | |
|---|---|
| Bionomics | This species is usually a two-host tick that is found in floodplains in semi-deserts and steppes, or vegetated hillsides and mountainsides are preferred habitats. |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Cattle, camels and sheep, immature stages tend to parasitize ground-feeding birds. |
| Oviposition | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |

*Rhipicephalus sanguineous*, Photo credit J. Stoffer WRBU

*Rhipicephalus sanguineous* (Latreille, 1806)
WRBU, 2016

| | |
|---|---|
| Bionomics | This species is a three-host tick that is prevalent in urban areas because of its close association with dogs. |
| Medical Importance | Crimean-Congo Hemorrhagic Fever, Boutonneuse Fever |
| Host Preference | Dogs but also feeds on camels, gerbils and, occasionally, humans. |
| Oviposition | *Rhipicephalus* sp. ticks, lay hundreds of eggs, generally in the dens of host animals, especially canines. |
| Questing Behavior | Adult *Rhipicephalus* sp. are passive in their host-questing activity (rarely moving more than 2 m) |

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# Ixodidae (hard) ticks

| | |
|---|---|
| Species Name | *Rhipicephalus annulatus* Say, 1821 |
| Bionomics | This species is primarily a one-host tick |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Cattle, but also feeds on other ungulates and less frequently, humans. |
| Oviposition | *Rhipicephalus* sp. ticks, lay hundreds of eggs, generally in the dens of host animals, especially canines. |
| Questing Behavior | Adult *Rhipicephalus* sp. are passive in their host-questing activity (rarely moving more than 2 m) |

| | |
|---|---|
| Species Name | *Hyalomma anatolicum anatolicum* (Koch, 1844) |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Camels, cattle, sheep, goats, dogs, and occasionally humans. |
| Oviposition | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |

| | |
|---|---|
| Species Name | *Hyalomma anatolicum excavatum* Koch, 1844 |
| Bionomics | This species tends to remain active even during winter months. |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Cattle and camels, and occasionally humans. Larvae and nymphs nearly always parasitize small mammals. |
| Oviposition | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |

| | |
|---|---|
| Species Name | *Hyalomma impeltatum* Schulze & Schlottke, 1930 |
| Bionomics | This species is usually a two-host tick that lives in scattered foci of semi-desert, savanna, and steppe biotopes. |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Camels, cattle, sheep and dogs |
| Oviposition | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |

| | |
|---|---|
| Species Name | *Hyalomma rufipes* Koch, 1844 |
| Medical Importance | Crimean-Congo Hemorrhagic Fever |
| Host Preference | Camels, cattle, dogs and, occasionally, humans. |
| Oviposition | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |

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# Ixodidae (hard) ticks

**I. Vector Surveillance and Suppression:** Military personnel should conscientiously use personal protective measures to prevent tick bites. Frequent self-examination and removal of ticks is important. Ticks should be handled as little as possible and not crushed. Troops should not sleep, rest or work near rodent burrows, huts, abandoned rural homes, livestock or livestock enclosures. Close contact with livestock should be avoided. Although there were no cases of CCHF in US military personnel during the Persian Gulf War, troops had frequent exposure to goats, cattle, camels and other domestic animals. Thirty percent of dogs randomly sampled in Israel, and 82 to 84% of the dogs belonging to two communities in which outbreaks of human spotted fever had occurred, were positive for *R. conorii*. Most dogs surveyed in Israel were heavily infested with vector ticks, and people who kept dogs had a higher incidence of boutonneuse fever. Troops should not be allowed to feed, befriend or adopt local dogs as pets. A satisfactory vaccine for Q fever has not been developed, and human vaccination has been hampered by the high rate of adverse reactions. Measures to identify and decontaminate Q fever infected areas and to vaccinate domestic animals are difficult, expensive and impractical. Military personnel should avoid consumption of local dairy products and contact with domestic animals, hides, and carcasses of dead animals. This is militarily significant, since troops had frequent exposure to domestic animals and animal carcasses during the Persian Gulf War. Soldiers should not rest, sleep, or work in animal sheds or other areas where livestock have been housed. For more information consult the AFPMB Technical Guide No. 26: Tick-Borne Diseases: Vector Surveillance and Control.

## II. Additional Resources:

Fryauff, D.J., Shoukry, M.A., Wassef, H.Y., Gray, G. & Schreck, C.E. 1998. Contact toxicity of permethrin-impregnated fabric to *Hyalomma anatolicum excavatum* (Acari: Ixodidae): effects of laundering and exposure and recovery times. Journal of Medical Entomology, 35(3): 335-339.

Pegram, R.G. 1982. Ticks (Acari: Ixodoidea) of the Yemen Arab Republic. Species infesting livestock. Bulletin of entomological research. 72(2): 215-228.

Pegram, R.G. 1989. Ticks (Acari: Ixodoidea) of the Yemen Arab Republic. II. The Rhipicephalus sanguineus (Latreille) group. Bulletin of entomological research (0007-4853), 79 (02): 259-275.

Ueckermann, E.A. 2006. The mites and ticks (Acari) of Yemen: an annotated check-list. Fauna of Arabia. 22: 243-256. Lall, H. K. 2000. Some observations on ticks of Yemen Arab Republic. Indian Veterinary Medical Journal(0250-5266), 24 (3), p. 181.

Wassef, H.Y. 1997. Further records of ticks (Acari: Argasidae and Ixodidae) from the Arabian Peninsula. Fauna of Saudi Arabia. 16: 63-72.

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# Flea Vector Species Profiles

# *Xenopsylla cheopis* (Rothschild, 1903)

**Bionomics:** *X. cheopis* occurs primarily where commensal rodents are found, particularly *Rattus norvegicus*. Hosts, as well as the primary vector, are more widely distributed in urban areas. In Saudi Arabia, Yemen and Oman, commensal rodents have a more limited coastal distribution, and are largely confined to urban areas. *X. cheopis* may occur sporadically in villages, when rats are present, or in highlands, associated with gerbils. The distribution of the Oriental rat flea is determined by the distribution of its hosts, primarily *R. rattus*, *R. norvegicus*, *Mus musculus*, *Meriones* spp. and *Psammomys* spp. (gerbils). Adult fleas feed exclusively on blood and utilize blood protein for egg production. After feeding on a rodent, the female Oriental rat flea lays several (2 to 15) eggs. Several hundred eggs may be laid during the entire life span. Oviposition most often occurs on the hairs of the host, although the eggs drop off and hatch in the nest or its environment. In locally humid environments, such as rodent burrows, eggs may hatch in as little as 2 days. Larvae live in the nest and feed on dried blood, dander, and a variety of organic material; they grow rapidly when temperature exceeds 25°C and the relative humidity is greater than 70%. The larval stages can be completed in as little as 14 days (at 30 to 32°C), or as long as 200 days when temperatures drop below 15°C or when nutrition is inadequate. Mature larvae pupate in cocoons, loosely attached to nesting material. Adult emergence from pupae may occur in as little as 7 days or as long as a year and is stimulated by carbon dioxide or host activity near the cocoon. Adult fleas normally await the approach of a host rather than actively search for one. They feed on humans when people and rodents live close together, but humans are not a preferred host. However, if rat populations decline suddenly due to disease or rat control programs, fleas readily switch to feeding on humans. The life span of adult *X. cheopis* is relatively short compared to that of other fleas species.

## Medical Importance:

*X. cheopis* is considered a primary vector of Plague and Murine Typhus.


*Xenopsylla cheopis* Female, Photo credit J. Stoffer WRBU

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# *Xenopsylla cheopis* (Rothschild, 1903)

**I. Vector Surveillance and Suppression:** The methods of flea surveillance depend upon the species of flea, the host, the ecological situation, and the objective of the investigation. Fleas can be collected from hosts or their habitat. The relationship of host density to flea density should be considered in assessing flea populations. It has been common practice for years to use a flea index (average number of fleas per host), especially in studies of rodent fleas. For *X. cheopis*, a flea index > 1.0 flea per host is considered high. The flea index has many limitations, since only adults are considered and then only while they are on the host. Fleas are recovered by combing or brushing the host or by running a stream of carbon dioxide through the fur while holding the host over a white surface. Flea abundance in the environment can be determined by counting the number of fleas landing or crawling in one minute on the lower parts of the legs of the observer. The trouser legs should be tucked into the socks to prevent bites. Flea populations can also be estimated by placing a white cloth on the floor in buildings or on the ground in rodent habitat and counting the fleas that jump onto the cloth. Various flea traps have been devised. Some use light or carbon dioxide as an attractant. Use of a modified Tullgren apparatus, based of the Berlase funnel, sifting and flotation of rodent nesting materials and dust and debris from infested buildings are effective methods of collecting fleas from the environment. Serologies of wild carnivores are sensitive indicators of enzootic plague. Control of enzootic plague over large areas is not feasible. Control efforts should be limited to foci adjacent to urban areas, military encampments, or other areas frequented by military personnel. If possible, cantonment sites should not be located in wild rodent habitat. Fleas quickly leave the bodies of dead or dying rodents in search of new hosts. Consequently, flea control must always precede or coincide with rodent control operations. Application of insecticidal dusts to rodent burrows is effective in reducing flea populations, but it is very labor intensive. Baiting with formulations that rodents carry to their dens or with baits containing systemic insecticides that kill fleas when they feed, has been effective but may pose environmental risks. Urban plague control requires that rodent runs, harborages and burrows be dusted with an insecticide labeled for flea control and known to be effective against local fleas. Insecticide bait stations can also be used. Rat populations should be suppressed by well planned and intensive campaigns of poisoning and concurrent measures to reduce rat harborages and food sources. Buildings should be rat-proofed to the extent possible to prevent rats from gaining entry. Insecticides recommended for flea control are listed in AFPMB Technical Guide No. 24, Contingency Pest Management Guide. Military personnel, especially those involved in rodent control, should use the personal protective measures discussed in AFPMB Technical Guide No. 36: Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. Active immunization with a vaccine of killed bacteria confers protection against bubonic plague (but not pneumonic plague) in most recipients for several months. Booster injections are necessary every six months. Vaccination should not be relied upon as the sole preventive measure. For more detailed information consult the AFPMB Technical Guide No. 40: Methods for Trapping and Sampling Small Mammals for Virologic Testing.

## II. Vector Identification:

Lewis, R. 1967. The fleas (Siphonaptera) of Egypt, an illustrated and annotated key. Journal of Parisitology, 53(4): 867-885.

## III. Additional Resources:

Flea Morphology (BYU, Fleas of the World)

**Note:** Fleas and tissues from suspected reservoirs or humans may be submitted for plague analysis to the Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector-borne Infectious Diseases, P.O. Box 2087, Foothills Campus, Fort Collins, Colorado 80522. Contact Centers for Disease Control and Prevention at (970) 221-6400 for additional information.

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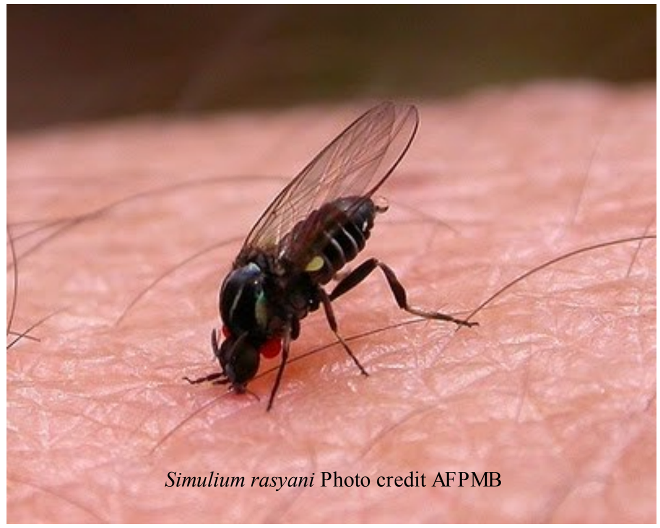
# Other Vector Species Profiles

# *Simulium rasyani* Garms, Kerner & Meredith, 1988



*Simulium rasyani* Photo credit AFPMB

**Bionomics:** After a bloodmeal, female black flies lay eggs on emergent vegetation along streams, or on logs and rocks that are splashed with water. Several masses of 150 to 500 eggs may be laid over a life span of 3 to 4 weeks. Eggs hatch in 2 to 3 days at temperatures of 25 to 30° C. Using caudal suckers and silken threads, black fly larvae attach to rocks in swift flowing streams, generally in mountainous areas of 300 to 1,200 m. They require relatively clean streams with high oxygen content. Larvae feed on small crustaceans, protozoa, algae, bacteria, and decaying bits of plants and animals suspended in the water. They progress through 6 to 9 (often 7) instars, and pupate 7 to 12 days after hatching, depending on temperature. Pupae are found in streams for about 1 to 2 weeks prior to emergence of adults. *Simulium damnosum* complex vectors are fierce biters that emerge in large numbers during the rainy season. Many generations can be produced (probably 5 to 10 per year in the Middle East) as long as streams are flowing. Females often circle in swarms around the lower extremities of human hosts. They are persistent biters that feed primarily outside and during the day. Engorgement usually requires only a few minutes. Bites may cause extreme irritation and itching in human or animal hosts. In sensitive persons, black fly bites can cause an acute allergic response. These flies are anthropophilic but also feed on cattle. Black flies are exophilic and not noted for entering human structures. After feeding, black flies fly to nearby shaded sites or protective vegetation. Black flies are strong fliers that can travel many kilometers (5 to 10 km or more) from their home streams. It is estimated that strong winds could easily carry them an additional 5 to 10 km from their breeding sites. Because most suitable streams flow primarily during the rainy season, the seasonal distribution of black flies is usually short. In Yemen, this season lasts from April to August, primarily in the Southwest part of the country bordering the Asir District of Saudi Arabia. Identification of species within the *S. damnosum* complex requires chromosomal analysis or molecular barcoding since they are morphologically identical.

**Medical Importance:** Members of the *Simulium damnosum* complex are the primary vectors of Onchocerciasis. *Simulium* (*Edwardsellum*) *rasyani* is a member of this complex, to date reported only from Yemen.

**Vector Surveillance and Suppression:** Control can rarely be achieved by directly attacking the adult black fly. Adults are susceptible to insecticides but are usually too widely dispersed for insecticidal spraying or fogging to achieve more than very temporary local control. Black fly populations are most concentrated in the immature aquatic stages. Control measures have been directed against black fly larvae with great success. Black fly larvae are susceptible to very low doses of many insecticides, including the biological control agent Bacillus thuringiensis (BTI). Aerial larviciding is usually necessary to treat rivers with extensive tributary systems. Reducing contact between black flies and military personnel is best achieved by using personal protective measures, such as wearing protective clothing and headgear and applying repellents.

## Vector Identification:


Dang, P.T. & Peterson, B.V. 1980. Pictorial keys to the main species and species groups within the *Simulium damnosum* Theobald complex occurring in West Africa (Diptera: Simuliidae). Tropenmedizin and Parasitologie, 31(1): 117-120.

Morales-Hojas, R. & Krueger, A. 2009. The species delimitation problem in the Simulium damnosum complex, blackfly vectors of onchocerciasis. Medical and Veterinary Entomology, 23(3): 257-268.


## Additional Resources:


Abdul-Ghani, R., Mahdy, M.A.K. & Beier, J.C. 2016. Onchocerciasis in Yemen: Time to take action against a neglected tropical parasitic disease. Acta Tropica: 162: 133-141.

Daniel, H.C., Dean, W.G., Ronald, C.N., Bruno, M. & Alfred, A.B. 1983. Sowda-Onchocerciasis in North Yemen: A Clinicpathologic Study of 18 Patients. The American Journal of Tropical Medicine and Hygiene, 32(1): 123-137.

Garms, R., Kerner, M & Meredith, S.E. 1988. *Simulium* (*Edwardsellum*) *rasyani* n.sp., the Yemen species of the *Simulium damnosum* complex. Tropical Medicine and Parasitology, 39(3): 239-244.

Richard-Lenoble, D., al Qubati, Y., Toe, L, Pisella, P.J., Gaxotte, P., al Kohlani, A. 2001. Human onchocerciasis and "sowda" in the Republic of Yemen. Bulletin de L'Académie Nationale de Médecine, 185(8): 1447-1459.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# *Pediculus humanus* Linnaeus, 1758

Blood-engorged head lice (*Pediculus humanus capitis* de Geer).
Photo Credit: AFPMB: James L. Occi

**Bionomics:** Human lice spend their entire life cycle (egg, 3 nymphal stages and adult) on the host. Eggs of body lice are attached to clothing at a rate of about 5 eggs per female per day. At 29 to 32 C, eggs hatch in 7 to 10 days. The maximum time eggs can survive unhatched is 3 to 4 weeks, which is important when considering the survival of lice in infested clothing and bedding. A blood meal is required for each of the 3 nymphal molts and for egg production in adults. The nymphal stages are passed in 8 to 16 days. Louse populations have the potential to double every 7 days. Adults live about 2 weeks and feed daily. Infestations of lice cause considerable irritation and scratching, which may lead to skin lesions and secondary infections. Body lice are commonly found in the seams and folds of clothing. Lice tolerate only a narrow temperature range and will abandon a dead host or one with a body temperature of 40o C or above. This contributes to the spread of lice and louse-borne disease. Human lice can survive without a host for only a few days.

**Medical Importance:** Human lice are known vectors of louse-borne relapsing fever and epidemic typhus.

**Vector Surveillance and Suppression:** Surveillance for body lice consist of examining individuals and their clothing for lice or nits (eggs). Body louse infestations have declined with higher standards of living, although infestations are still common in some Middle Eastern populations. Military personnel should avoid close personal contact with infested persons and their belongings, especially clothing and bedding. Dry cleaning or laundering clothing or bedding in hot water (55o C for 20 minutes) will kill eggs and lice. Control of epidemics requires mass treatment of individuals and their clothing with effective insecticides. The permethrin-treated uniform is extremely effective against lice. Since lice cannot survive away from the human host, application of insecticides to buildings, barracks or other living quarters is not necessary.

## Vector Identification:

University of Florida, Entomology and Nematology, Featured Creatures: Body Louse

## Additional Resources:

CDC: Pediculosis Background

Al-Maktari, M.T. 2008. Head louse infestations in Yemen: prevalence and risk factors determination among primary schoolchildren, Al-Mahweet Governorate, Yemen. Journal of the Egyptian Society of Parasitology. 38(3): 741-748.

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# Personal Protective Measures

**Field Uniform:** 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. Proper wearing of the field uniform is essential to minimize skin exposure (Figure 2-1). If the risk of heat stress is a factor in a particular environment, common sense or advice from medical or Preventive Medicine personnel should dictate when the following recommendations are not practical:

1. Tuck pant legs into boots or into socks. This forces non-flying pests, such as ticks, chiggers, stinging ants and spiders, to climb up the outside of the pant legs, thus decreasing access to the skin and increasing the likelihood of their being seen.
2. Roll sleeves down and close the collar to help protect the arms and neck from arthropod attack. This is especially important in malaria-endemic regions when Anopheles species bite from dusk until dawn.
3. It is difficult for pests to bite through the uniform fabric unless it is pulled tightly against the skin. Therefore, the uniform should be worn loosely, with an undershirt worn underneath the coat to act as an added barrier12,13. The undershirt should be tucked into the pants to decrease access by crawling arthropods at the waistline. Mosquitoes can easily bite through tight-fitting material such as that used for the combat uniform.
4. The field cap and its brim help protect the head and face. Some biting insects tend to avoid the shaded area of the face under the cap's brim.
5. Uniforms that are treated with permethrin provide protection only on the covered portion of the body. Mosquitoes will still readily feed on the hands, neck and head. It is essential to apply an approved insect repellent to exposed body surfaces. Reapplication is advised according to the label.

Proper wearing of field uniform minimizes exposure to arthropod attack (AFPMB)

*For more information on personal protective measures, consult [AFPMB Technical Guide No. 36: Personal Protective Measures Against Insects and Other Arthropods of Military Significance.]()*

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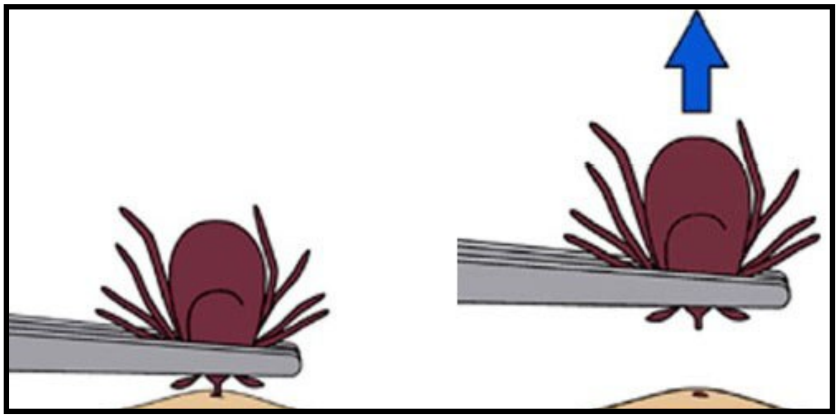
# Personal Protective Measures

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 TIM 36,

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, repellents, 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. 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 INSECT 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 TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance (1996).

***For more information on personal protective measures, consult AFPMB Technical Guide No. 36: Personal Protective Measures Against Insects and Other Arthropods of Military Significance.***

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| **Checklist to the Mosquitoes of Yemen** <br> **(WRBU Catalog of the Culicidae)** |
|---|
| *Aedes* (*Aedimorphus*) *hirsutus adenensis* Edwards |
| *Aedes* (*Aedimorphus*) *natronius* Edwards |
| *Aedes (Aedimorphus) vexans* (Meigen)* |
| *Aedes* (*Aedimorphus*) *vexans arabiensis* Patton |
| *Aedes* (*Fredwardsius*) *vittatus* (Bigot) |
| *Aedes* (*Ochlerotatus*) *caballus* (Theobald) |
| *Aedes (Ochlerotatus) caspius* (Pallas)* |
| *Aedes* (*Ochlerotatus*) *chelli* (Edwards) |
| *Aedes (Stegomyia) aegypti* (Linnaeus)* |
| *Aedes* (*Stegomyia*) *grantii* (Theobald) |
| *Anopheles* (*Anopheles*) *coustani* Laveran |
| *Anopheles (Cellia) arabiensis* Patton* |
| *Anopheles* (*Cellia*) *cinereus hispaniola* Theobald |
| *Anopheles* (*Cellia*) *cinereus* Theobald |
| *Anopheles (Cellia) culicifacies* Giles* |
| *Anopheles* (*Cellia*) *demeilloni* Evans |
| *Anopheles* (*Cellia*) *dthali* Patton |
| *Anopheles* (*Cellia*) *fluviatilis* James** |
| *Anopheles* (*Cellia*) *gambiae* Giles** |
| *Anopheles* (*Cellia*) *pharoensis* Theobald** |
| *Anopheles* (*Cellia*) *pretoriensis* (Theobald) |
| *Anopheles (Cellia) sergentii* (Theobald)* |
| *Anopheles* (*Cellia*) *rhodesiensis rupicolus* Lewis |
| *Anopheles* (*Cellia*) *turkhudi* Liston |
| *Culex* (*Culex*) *decens* Theobald |
| *Culex* (*Culex*) *duttoni* Theobald |
| *Culex* (*Culex*) *laticinctus* Edwards |
| *Culex* (*Culex*) *mattinglyi* Knight |
| *Culex (Culex) pipiens* Linnaeus* |
| *Culex (Culex) quinquefasciatus* Say* |
| *Culex* (*Culex*) *simpsoni* Theobald |
| *Culex (Culex) sinaiticus* Kirkpatrick |
| *Culex* (*Culex*) *sitiens* Wiedemann |
| *Culex* (*Culex*) *theileri* Theobald** |
| *Culex* (*Culex*) *tritaeniorhynchus* Giles** |
| *Culex (Culex) univittatus* Theobald* |
| *Culex* (*Culiciomyia*) *nebulosus* Theobald |
| *Culex* (*Maillotia*) *arbieeni* Salem |
| *Culex* (*Maillotia*) *salisburiensis* Theobald |
| *Culex (Oculeomyia) bitaeniorhynchus* Giles* |
| *Culiseta* (*Allotheobaldia*) *longiareolata* (Macquart) |

* indicates vector species, click to view vector ecology profile

** indicates vector species, but not considered a major vector in Yemen

# Bionomics Table: Mosquito Vectors of Yemen

| Species Name | Medical Importance | Biting Times | Host Preference | Feeding Behavior | Resting Behavior |
|---|---|---|---|---|---|
| *Anopheles* (*Cel.*) *arabiensis* Patton, 1905 | Malaria | 19:00-03:00 | Primarily Zoophilic but known to be Anthropophilic on occasion | Exophagic | Primarily Exophillic but known to be Endophillic on occasion |
| *Anopheles* (*Cel.*) *culicifacies* s.l. | Malaria | 23:00-00:00 | Primarily Zoophilic but known to be Anthropophilic | Endophagic and Exophagic | Primarily Endophillic but known to be Exophillic |
| *Anopheles* (*Cel.*) *sergentii* s.l. | Malaria | Unclear | Primarily Zoophilic but known to be Anthropophilic | Exophagic and Endophagic | Endophillic (natural or man-made) |
| *Aedes* (*Stg.*) *aegypti* (Linnaeus, 1762) | Dengue, Chikungunya, Zika viruses | 06:00-18:00 | Primarily Anthropophilic | Exophagic and Endophagic | Exophilic and Endophillic |
| *Culex* (*Cux.*) *pipiens* Linnaeus, 1758 | West Nile and Sindbis viruses, Bancroftian filariasis | 18:00-06:00 | Anthropophilic and Zoophilic | Exophagic and Endophagic | Exophilic and Endophillic |
| *Culex (Cux.) univittatus* Theobald, 1901 | West Nile and Sindbis viruses | 18:00-06:00 | Anthropophilic and Zoophilic | Exophagic and Endophagic | Exophilic and Endophillic |
| *Culex* (*Cux.*) *quinquefasciatus* Say, 1823 | West Nile virus | 18:00-06:00 | Primarily Anthropophilic and Zoophilic | Exophagic and Endophagic | Exophilic and Endophillic |
| *Culex* (*Ocu.*) *bitaeniorhynchus* Giles, 1901 | Sindbis virus | 18:00-06:00 | Anthropophilic and Zoophilic | Exophagic and Endophagic | Exophilic and Endophillic |
| *Aedes* (*Och.*) *caspius* (Pallas, 1771) | West Nile virus | 06:00-18:00 | Anthropophilic and Zoophilic | Exophagic and Endophagic | Exophilic and Endophillic |

# Bionomics Table: Tick Vectors of Yemen

| Species Name | Medical Importance | Life Cycle | Host Preference | Oviposition |
|---|---|---|---|---|
| *Amblyomma variegatum* Fabricius 1794 | Crimean-Congo Hemorrhagic Fever (CCHF) | No data | Sheep and cattle, and occasionally humans | No data |
| *Hyalomma dromedarii* Koch, 1844 | Crimean-Congo Hemorrhagic Fever (CCHF) | This species may be either a two- or three-host tick | Camels, cattle, goats, dogs, small mammals, lizards and occasionally humans | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |
| *Hyalomma truncatum* Koch, 1844 | Crimean-Congo Hemorrhagic Fever (CCHF) | This species is usually a two-host tick that is found in floodplains in semi-deserts and steppes, or vegetated hillsides and mountainsides are preferred habitats. | Cattle, camels and sheep, immature stages tend to parasitize ground-feeding birds | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |
| *Rhipicephalus sanguineous* (Latreille, 1806) | Crimean-Congo Hemorrhagic Fever (CCHF), Boutonneuse Fever | This species is a three-host tick that is prevalent in urban areas because of its close association with dogs. | Dogs but also feeds on camels, gerbils and, occasionally, humans. | *Rhipicephalus* sp. ticks, lay hundreds of eggs, generally in the dens of host animals, especially canines. |
| *Rhipicephalus annulatus* Say, 1821 | Crimean-Congo Hemorrhagic Fever (CCHF) | This species is primarily a one-host tick. | Cattle, but also feeds on other ungulates and less frequently, humans. | *Rhipicephalus* sp. ticks, lay hundreds of eggs, generally in the dens of host animals, especially canines. |

# Bionomics Table: Tick Vectors of Yemen

| Species Name | Medical Importance | Bionomics | Host Preference | Oviposition |
|---|---|---|---|---|
| *Hyalomma anatolicum anatolicum* (Koch, 1844) | Crimean-Congo Hemorrhagic Fever (CCHF) | No data | Camels, cattle, sheep, goats, dogs, and occasionally humans. | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |
| *Hyalomma impeltatum* Schulze & Schlottke, 1930 | Crimean-Congo Hemorrhagic Fever (CCHF) | This species is usually a two-host tick that lives in scattered foci of semi-desert, savanna, and steppe biotopes. | Camels, cattle, sheep and dogs | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |
| *Hyalomma rufipes* Koch, 1844 | Crimean-Congo Hemorrhagic Fever (CCHF) | No data | Camels, cattle, dogs and, occasionally, humans. | *Hyalomma* sp. ticks, the number of eggs laid is variable, ranging from hundreds in rodent burrows to thousands on open ground or vegetation. Eggs usually hatch within 30 days. |
| *Ornithodoros savignyi* | *Ornithodoros* sp. are known vectors of Tick-borne relapsing fever. | This species inhabit sheltered areas, such as caves, stables, and rock outcroppings. | It feeds on camels and goats but may feed on humans. | The number of eggs deposited may total several hundred over the life span of the female, with up to 8 batches of eggs produced. |

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