

**Vector-Borne Diseases: Impact of Climate Change on Vectors and Rodent Reservoirs**  
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## Mosquito-borne viruses in Europe

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We can distinguish three categories of mosquito-borne viruses in Europe: (i) human pathogenic and autochthonous; (ii) human pathogenic and imported; (iii) pathogenic for other vertebrates than humans.

### 1. Mosquito-borne human pathogenic viruses autochthonous in Europe

**Sindbis virus** (*Alphavirus, Togaviridae*); synonyms Ockelbo, Pogosta and Karelian fever viruses

History: first isolated 1952 by R. M. Taylor & al. from *Culex univittatus* mosquitoes collected in Sindbis village, Nile Delta (Egypt). In Europe, first isolated by E. Ernek & al. from a Reed Warbler (*Acrocephalus scirpaceus*) caught in Western Slovakia, July 1971. SINV is very widely distributed, it occurs in Africa, Eurasia and Australia.

Human disease: fever 3-4 d. with headache, myalgia, arthralgia (polyarthritits), malaise, conjunctivitis, pharyngitis and rash (skin vesicles on the trunk and limbs while the face remains usually unaffected). Acute illness lasts up to 10 d., but fatigue and tendon pains may persist for several weeks or months, and chronic arthritis may develop in some patients. No lethality. An extensive epidemic in Fennoscandia since 1981.

Distribution in Europe (a map). In Czechland, SINV has not yet been isolated, but antibodies are present in some birds and domestic and wild mammals though at a relatively low frequency.

Vectors in Europe: *Culex pipiens*, *Cx. torrentium*, *Culiseta morsitans*, *Mansonia richiardii*, *Aedes communis*, *Ae. cinereus*, *Ae. cinereus*, *Ae. excrucians*, *Anopheles hyrcanus*.

Hosts: largely wild passeriform birds (e.g. *Turdidae*), less often rodents and amphibians.

Natural foci: mainly wetland ecosystems in diverse biomes.

**West Nile virus** (*Flavivirus, Flaviviridae*); synonym Rabensburg virus

History: First isolated 1937 from a patient's blood by K. C. Smithburn & al. in Uganda. First recorded epidemics in Israel in 1950's, then in South Africa at least 3000 cases in 1974. Soon recognized as one of the most widespread flaviviruses, distributed through Africa, Asia, Europe, and Australia; since 1999 also present in America.

Human disease: moderate to high fever, headache, sore throat, backache, myalgia, arthralgia, fatigue, anorexia, nausea (vomiting), rash, lymphadenopathy, acute aseptic

meningitis or encephalitis; less often myocarditis, pancreatitis, hepatitis; lethality 5-10% (majority of fatal cases recorded in persons aged >60 years).

Distribution in Europe (a map). In Czechland, WNV was isolated in 1997 and 1999 from *Cx. pipiens* mosquitoes, and five human cases of WNF were described in South Moravia (Hubálek & al. 1999). The two virus strains were later sequenced and found to represent either a new, 3rd genomic lineage of WNV, or possibly even a new flavivirus (Rabensburg) within the Japanese encephalitis group of flaviviruses (Bakonyi & al. 2005).

European vectors: WNV was isolated from *Culex pipiens*, *Cx. modestus*, *Mansonia richiardii*, *Aedes cantans*, *Ae. caspius*, *Ae. excrucians*, *Ae. vexans*, and *Anopheles maculipennis* group.

Hosts: largely wild birds. In Europe, WNV was isolated from a number of wild birds, part of them being migratory.

Natural foci: wetland ecosystems.

**Ťahyňa virus** (California group, *Orthobunyavirus*, *Bunyaviridae*); synonym Lumbo virus

History: first isolated 1958 from *Aedes vexans* and *Ae. caspius* mosquitoes in Ťahyňa and Křižany villages, E. Slovakia (V. Bárdoš & V. Danielová). This is the first mosquito-borne virus of vertebrates isolated in Europe. An antigenically identical virus Lumbo was later reported from Africa. TAHV occurs in Eurasia and Africa.

Human disease: 'Valtice fever', an influenza-like illness occurring in summer and early autumn mainly in children, with sudden onset of fever (3-5 d.), headache, malaise, conjunctivitis, pharyngitis, myalgia, nausea, gastrointestinal disorders, anorexia, occasional arthralgia, stiff neck or other signs of the CNS involvement, sometimes bronchopneumonia. No lethality (contrary to the N.-American La Crosse virus).

Distribution in Europe (a map). In Czechland, it occurs in southern Moravia, much less frequently in northern Moravia, Silesia, southern, central and western Bohemia.

Vectors: mainly culicine mosquitoes *Aedes vexans*, *Ae. caspius*, *Ae. cinereus*, *Ae. cantans*, *Ae. communis* (N. Europe), *Culiseta annulata*, *Culex modestus*, sporadically *Anopheles hyrcanus*.

Hosts: European hare, hedgehog, rodents.

Natural foci: inundated lowland habitats (floodplain forest ecosystem) including periurban areas, in diverse biomes.

**Snowshoe hare virus** (California group, *Orthobunyavirus*, *Bunyaviridae*)

History: first isolated 1959 by W. Burgdorfer from an emaciated snowshoe hare (*Lepus americanus*) in Montana, U.S.A. In Europe, first isolated 1986 by A.M. Butenko, S.D. Lvov et al. from *Aedes communis* in N. European Russia. Closely related to Tahyna and LaCrosse viruses.

Human disease: fever, headache, vomiting, sometimes CNS affection.

Distribution in Europe: Northern Europe.

Vectors: *Aedes canadensis*, *Ae. communis*, *Ae. cinereus*, *Ae. punctor*, *Ae. cataphylla*, *Culiseta inornata*, etc.

Hosts: snowshoe hare; lemmings and other rodents.

Natural foci: tundra and taiga biomes.

**Inkoo virus** (California group, *Orthobunyavirus*, *Bunyaviridae*)

History: first isolated 1964 by M. Brummer-Korvenkontio & al. from *Aedes communis/punctor* mosquitoes collected in South Finland, 1964.

Human disease: influenza-like illness or aseptic meningitis characterized by sudden onset of fever, weakness, headache, retrobulbar pain, conjunctivitis, pharyngitis, and occasional rash. The closely related Jamestown Canyon virus causes CNS infections among adults in North America.

Distribution in Europe (a map). The virus is obviously restricted to northern Europe, including Russia. In Czechland, the virus has not been detected, and probably is absent.

Vectors: *Aedes communis*, *Ae. punctor*, *Ae. hexodontus*.

Hosts: *Lepus timidus*, *Alces alces* (?).

Natural foci: open farmland with water pools at northern latitudes.

**Batai virus** (*Orthobunyavirus*, *Bunyaviridae*); synonyms Čalovo and Chittoor viruses

History: first isolated 1955 by B. Elisberg & E. L. Buescher from *Culex gelidus* collected on Kuala Lumpur (Malaysia) grazing grounds. Antigenically identical Čalovo virus was isolated in Europe later (1960) by V. Bárdoš & E. Čupková from *Anopheles maculipennis* s.l. mosquitoes near Čalovo, South Slovakia.

Human disease: serological data have indicated an association with influenza-like illness accompanied by malaise, myalgia and anorexia (F. Sluka & V. Bárdoš). BATV was also isolated from the blood of febrile patients in Thailand and Sudan, and antigenically similar African Ilesha virus was described as the cause of human febrile illness with rash or even haemorrhagic fever including one fatal case.

Distribution in Europe (a map). In Czechland, the virus was isolated by A. Smetana & al. from *Anopheles maculipennis* s.l. mosquitoes in South Moravia in 1966, and antibodies occur at a low frequency in domestic and some wild mammals, especially ruminants, less often in birds.

Vectors: *Anopheles maculipennis* s.l., *An. claviger*.

Hosts: domestic pig, ruminants, birds.

Natural foci: agroecosystems (farms, villages); domestic animal–zoophilic mosquito cycle.

## 2. Exotic (imported) mosquito-borne human pathogenic viruses in Europe

In 2006-2007, tens of **chikungunya** fever cases have been imported from the islands of Indian Ocean (Reunion, etc.) and Indian subcontinent to many European countries: France, U.K., Germany, Italy, Czechland, etc.

**Dengue** human cases in Europe: several tens are introduced each year from tropical regions, as reported by many European countries.

Occasionally, also **yellow fever** cases are being imported in Europe.

**Epidemics** of imported exotic mosquito-borne virus infections in Europe:

- Yellow fever: Portugal, Spain, XVIII-XIX century (the largest outbreaks in 1741 and 1802-1821: about 100,000 victims); France (Saint Nazaire), 1860s; England (Swansea), 1865.
- Dengue: a focus in Athens, 1927-28 (650,000 patients, 1060 died).
- Chikungunya: an Italian focus Ravenna province (Castiglione di Cervia) of Emilia-Romagna, September 2007 (≥80 confirmed human cases).

Such mosquito-borne virus outbreaks are determined by the import and presence of competent vectors of the particular disease, i.e. *Aedes aegypti* in the past (YFV, DENV), and *Ae. albopictus* recently (CHIKV) in Europe.

In general, the mosquito-borne virus importation to Europe is possible *via*: viraemic travellers; introduction of infected mosquitoes (incl. larvae, puppae, eggs: *Ae. albopictus* etc.) on planes, ships, cars (international traffic and trade); trade in domestic, pet and ZOO infected vertebrates; infected migratory birds (WNV).

## 3. Mosquito-borne viruses not pathogenic to man in Europe

**Lednice** bunyavirus (Turlock group) and **Usutu** flavivirus (Japanese encephalitis group) are associated with wild birds, and occur in Central Europe, though they are of African origin. USUV is pathogenic largely for passeriform birds and raptors ([Weissenböck & al. 2002](#)).

**Favourable ecological factors** for (autochthonous and imported) mosquito-borne viruses: abundance of wild vertebrates and vectors; intense summer precipitations, floods; summer temperatures and drought; appropriate habitats, e.g., humid building basements.

Virus perpetuation is possible: in overwintering mosquitoes (*Culex*, *Culiseta* or *Anopheles* females); by transovarial transmission in mosquitoes; during chronic infection of vertebrates.

**Weather and climate effects** on mosquito-borne viruses (under climate warming scenario):

- higher virus replication rate in vector mosquitoes (a shortened extrinsic incubation period)
- increased vector populations
- expanding range of vectors – northwards (e.g. *Culex modestus*)
- but: higher mortality rate of the vector population.

**Epidemiological surveillance** = an approach combining epidemiology with ecology, consisting of: routine diagnosis of human disease; reporting incidence of human disease; monitoring animal disease (if it exists); monitoring mosquito vector populations; testing mosquito vector infection rates; domestic+wild vertebrate serosurveys; monitoring ecological factors.

## Conclusions

Eleven mosquito-borne viruses have been reported in Europe to date: six of them are autochthonous and cause human infections (Sindbis, West Nile, Ťahyňa, Snowshoe hare, Inkoo, and Batai viruses); three of the viruses are exotic, being occasionally imported to Europe (Chikungunya, dengue and yellow fever); and two of the viruses are associated with birds and are not pathogenic to humans (Lednice, Usutu). Mosquito-borne virus outbreaks are strictly determined by the presence and/or import of particular competent vectors of the disease. Ecological variables affect mosquito-borne viruses considerably, the main factors are: presence of appropriate habitats for mosquitoes, e.g., wetlands, small water pools, or humid building basements; abundance of mosquito vectors and their vertebrate hosts; intense summer precipitations, floods; summer temperatures and drought;. A surveillance for mosquito-borne viruses, the diseases they cause, and their vectors in Europe is highly recommendable.

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