



## WEST NILE VIRUS

ANIMAL GROUP AFFECTED	TRANSMISSION	CLINICAL SIGNS	FATAL DISEASE ?	TREATMENT	PREVENTION & CONTROL
Birds, Equidae, Humans, other mammals, Reptiles, amphibians	Mosquitoes, also ticks, possibly other arthropods; direct (oral); iatrogenic	Neurological, general, sudden death	Yes. High percentage birds with some strains; 30% of clinically affected horses.	Supportive. Immune plasma or serum may be beneficial.	Vaccination, if vaccine available. Mosquito control e.g. local habitat removal, exclude from houses, use repellents.

<b>Fact sheet compiled by</b> Debra Bourne, Wildlife Information Network, UK	<b>Last update</b> March 2009
<b>Fact sheet reviewed by</b> Paul Duff, Robert G. McLean	
<b>Susceptible animal groups</b> Most bird and mammal species, also reptiles and amphibians may be infected. Disease may occur in horses (and humans) infected with a variety of strains of the virus. Infection with some strains isolated in Israel, North America and Hungary may cause severe and fatal disease in corvids (especially American crow - <i>Corvus brachyrhynchus</i> ), raptors and many other birds, particularly New World but also Old World species; in mammals including horses and less commonly various other mammals e.g. rodents, camelids, ruminants and carnivores. Disease has occurred in reptiles (American alligator - <i>Alligator mississippiensis</i> and Crocodile monitor - <i>Varana salvidorii</i> ) infected with the strains circulating in the New World.	
<b>Causative organism</b> West Nile Virus, in the Japanese encephalitis subgroup of the Flaviviridae. Strains found historically in Europe and Africa sometimes cause disease in equines & humans but not disease due to natural infection in birds, but this appears to be changing. A lineage 1 strain causing clinical, sometimes fatal, disease in birds was found in Israel in domestic geese ( <i>Anser anser domesticus</i> ) goslings in 1997; WNV in North America is closely related, as is a strain causing deaths of geese in Hungary in 2003. Recent fatal infection in eagles in Spain with WNV lineage 1a and in birds of prey in Hungary with a lineage 2 strain. Experimental infection of <i>Corvus brachyrhynchus</i> with NY99 (USA isolate), a Kenyan WNV and a Kunjin virus showed NY99 was most virulent. Strain WN02 (shorter extrinsic incubation in mosquitoes than NY99) now dominates in USA.	
<b>Zoonotic potential</b> Yes. High zoonotic potential via mosquito bite, also iatrogenic e.g. accidental inoculation.	
<b>Distribution</b> Africa, Madagascar, Europe, Asia, Australia (Kunjin virus). North America (first detected New York, 1999, found across most of the continental USA and in Canada in Alberta, Manitoba, New Brunswick, Nova Scotia, Ontario, Quebec and Saskatchewan), Central America (first detected autumn 2002), Caribbean (first detected Dominican Republic autumn 2002) and South America (first detected Columbian horses, 2004; first detected Argentina 2005-2006). In Europe, recent epidemics occurred in horses in Italy (1998), France (2000; a few cases in 2003 - also in humans), and in Hungary in domestic geese (2003), also in Israel in 1997-2000 in horses & humans (N.B. one case in 2005) and domestic geese, and in horses in Morocco and Oman in 2003. Human outbreaks in Romania (1996), Russia	



(1999), Tunisia (1997).

**Transmission**

Mainly by mosquitoes, particularly *Culex* spp.; also ticks and possibly other blood feeding arthropods. Not all vertebrate hosts develop viraemia sufficient for effective transmission to mosquitoes. Many birds develop sufficient viraemia, also some species of amphibians (*Rana ridibunda* – Marsh frog), reptiles (*Alligator mississippiensis* - American alligator) and mammals (some small rodents, cottontail rabbits, possibly cats, possibly other species; not usually horses, humans or dogs). Also direct contact between birds (probably oral transmission – shed orally and cloacally) and experimentally orally e.g. by feeding of birds on infected mosquito, bird or mouse and by feeding domestic cats on infected mice. In humans, transmission has been reported by accidental inoculation, blood transfusion, organ transplant, via breast milk and transplacentally. In hamsters, virus is detectable in urine for long periods.

**Incubation period**

Usually short. In *Corvus brachyrhynchus* 5-8 days. In humans 3-15 days. Eight to 58 days reported in horses.

**Clinical symptoms**

May be no clinical signs. If clinical illness occurs, nervous and general signs, or sudden death.

**Birds:** usually asymptomatic but may cause non-specific signs e.g. depression, anorexia, weakness, leg paralysis, weight loss and recumbency, or neurological signs e.g. abnormal head or neck posture, ataxia, tremors, circling, disorientation, paresis (unilateral or bilateral), visual impairment, dysphagia and seizures. Sudden death may also occur.

**Horses:** Neurological signs in about a tenth of infected equids. Sometimes early fever. Ataxia, weakness, paresis or paralysis and recumbency, muscle fasciculation, apparent blindness, proprioceptive defects, altered mental status, lip droop and tooth grinding may be noted. Acute onset or progression. May recover, with (sometimes without) supportive treatment. Horses becoming recumbent, those with caudal paresis, and those older than five years of age are more likely to die/need euthanasia (30% mortality). Full resolution of ataxia in survivors may take weeks-months. Relapses reported, also continuing neurological signs e.g. locomotor problems and/or behavioural changes persisting six months or more after the onset of illness.

**Other mammals:** often asymptomatic. Clinical illness may include mild non-specific signs such as lethargy and reduced appetite and/or overt neurological signs such as head tilt, torticollis, ataxia and incoordination, tremors, hindlimb paralysis, tetraplegia, loss of righting ability and recumbency. Pyrexia may be present. Continuing neurological signs may occur in survivors.

**Reptiles:** neurological signs and fatal infection reported.

**Humans:** WN Fever: headache, fever, myalgia/arthritis, fatigue, +/- rash +/- enlarged lymph nodes. WN encephalitis: typical arboviral encephalitis or meningitis; neurological signs may be severe. Muscle weakness, paresis or paralysis may occur.

**Post mortem findings**

**GROSS PATHOLOGY**

**Birds:** commonly brain haemorrhage, splenomegaly, meningoencephalitis and myocarditis (may be no gross lesions on necropsy).

**Horses:** Often no gross CNS lesions, occasionally e.g. submeningeal oedema, meningeal congestion, cerebral surface congestion and congestion within the spinal cord. Lung congestion and oedema common in an outbreak in Morocco.

**Other mammals:** often no relevant gross lesions.

**HISTOLOGY**

**Birds:** mild to severe encephalitis and meningitis, with infiltrates and perivascular cuffing - mainly lymphocytes and plasma cells. Myocarditis (mild to severe), sometimes nephritis, hepatitis, pneumonitis; sometimes lesions in e.g. pancreas, adrenals. Sometimes mild focal subacute pectoral myositis. Endophthalmitis in *Buteo jamaicensis* and *Accipiter cooperi*.

**Horses:** nonsuppurative encephalitis - neuronophagia, multifocal gliosis; may be perivascular cuffing with lymphoplasmacytic and histiocytic cells. Lesions may be most severe in the lower brain stem and spinal cord.

**Other mammals:** typically nonsuppurative encephalitis (e.g. lymphocytic perivascular cuffing, mild necrosis, focal gliosis) and myocarditis. Lesions may also be seen in the liver, lungs and/or kidneys.

**Diagnosis**

Clinical signs are not pathognomonic but typical neurological signs may suggest infection when occurring during an outbreak. Pathological findings do not allow definitive diagnosis.



**Detection of antibodies:** serological evidence of the development of WNV antibodies. Four-fold increase in antibody titre using the plaque reduction neutralization test (PRNT) in paired acute and convalescent sera. Indirect ELISA as a screening test but cross-reacts with other flaviviruses so positive results must be confirmed using the PRNT. In equids, IgM is short-lived, so detection of IgM by ELISA indicates recent infection with WN virus or a closely related flavivirus. A blocking ELISA using monoclonal antibody can detect WNV-specific antibodies in serum from any vertebrate species.

**Detection of virus/virus antigen:** isolation of WN virus from, or demonstration of WN viral antigen or genomic sequences in, tissue, blood, cerebro-spinal fluid (CSF), or other body fluid. RT-PCR is a sensitive test for virus RNA detection; NASBA and VecTest are also used. Virus isolation and immunohistochemistry are about equal to one another in sensitivity.

**Material required for laboratory analysis**

**From birds:** serum from live birds, preferably paired (acute and convalescent) samples, or oral swabs, or feather pulp. From dead birds, kidney, heart and/or brain; oral and cloacal swabs from carcasses of highly susceptible species such as corvids and tested for WNV by VecTest or NASBA.

**From equids:** from live animals serum (CSF may also be tested). From dead individuals brain, several segments of spinal cord (cervical, thoracic and lumbar), and cervical or lumbar CSF.

**From other mammals:** from live animals, paired serum samples. From dead: kidney, brain, +/-other tissues.

**N.B.** Tissue samples should be divided, with half of each sample frozen and half placed in formalin.

**OIE Reference Laboratory**

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**Relevant diagnostic laboratories**

In the USA:

- National Wildlife Health Center (USGS), 6006 Schroeder Road, Madison, Wisconsin 53711, USA Tel: +1 (608) 270-2400; Fax: (608) 270-2415 Website: <http://www.nwhc.usgs.gov>
- Division of Vector-Borne Infectious Diseases, National Center for Infectious Diseases CDC, PO Box 2087, Fort Collins, Colorado 80522. <http://www.cdc.gov/ncidod/dvbid/index.htm>
- Wadsworth Center (New York State Department of Health), ESP-P.O. Box 509, Albany, New York 12201-0509 USA. Information Tel: +1 (518) 474-2160 Website: <http://www.wadsworth.org/rabies>

**Treatment**

Supportive and symptomatic treatment: e.g. intravenous fluid support and nutrition in affected individuals unable to eat, sling support for severely ataxic individuals, protection from and treatment of traumatic injuries occurring due to ataxia and recumbency. There are no confirmed effective antiviral treatments. Some humans have been treated with immune serum. In the USA, a serum based product (Novartis Animal Health) and a plasma based product (Lake Immunogenics, Inc.), have been marketed for use in horses.

**Prevention and control in zoos**

Vaccines have been developed in the USA for use in equids: (1) A killed vaccine (West Nile - Innovator, Fort Dodge Animal Health) has also been used in various other species. Immunogenic in llamas, not in rhino; (2) a recombinant vaccine in a canarypox vector (RECOMBITEK® Equine West Nile vaccine, Merial Animal Health). Immunogenic in rhino. (3) West Nile-Innovator® DNA vaccine (Fort Dodge Animal Health; licensed by USDA 2005, not commercially available); 4) A Flavivirus chimera vaccine, for use in horses, (PreveNile, Intervet). Vaccines 1 and 2 need an initial course of two injections, with a yearly booster recommended; vaccine 4 is a single initial injection, yearly booster. **Birds:** variable responses of different bird species to different vaccines e.g. a DNA vaccine reduced mortality in fish crows (*Corvus ossifragus*) and has been used in raptors while in penguins there was better response to the killed vaccine than to a plasmid DNA vaccine. A modified live vaccine has been used in domestic geese in Israel.

**Suggested disinfectant for housing facilities**

Susceptible to: 3-8% formaldehyde, 2% gluteraldehyde, 2-3% hydrogen peroxide, 500-5000 ppm available chlorine, alcohol, 1% iodine, phenol iodophores, other organic solvents/detergents. Disinfection may be useful if there is concern



about virus being spread in excretions and secretions from infected animals.

**Notification****Guarantees required under EU Legislation****Guarantees required by EAZA Zoos****Measures required under the Animal Disease Surveillance Plan****Measures required for introducing animals from non-approved sources****Measures to be taken in case of disease outbreak or positive laboratory findings****Conditions for restoring disease-free status after an outbreak****Contacts for further information****References**

1. Bakonyi, T., Ivanics, E., Erdelyi, K., Ursu, K., Ferenczi, E., Weissenbock, H. & Nowotny, N. (2006) Lineage 1 and 2 strains of encephalitic West Nile virus, central Europe. *Emerg. Inf. Dis.* 12, 618-623
2. Blitvich, B.J. (2008) Transmission dynamics and changing epidemiology of West Nile virus. *Animal Health Research Reviews* 9, 71-86
3. Blitvich, B.J., Marlenee, N.L., Hall, R.A., Calisher, C.H., Bowen, R.A., Roehrig, J.T., Komar, N., Langevin, S.A. & Beaty, B.J. (2003) Epitope-blocking enzyme-linked immunosorbent assays for the detection of serum antibodies to West Nile virus in multiple avian species. *J. Clin. Microbiol.* 41: 1041-1047
4. Bourne, D. (2008) Wildpro v 4.3 West Nile Virus: Equine Update 2008. Wildlife Information Network, London, UK. [www.wildlifeinformation.org](http://www.wildlifeinformation.org). ISBN 978-0-9551628-4-8
5. Brault, A.C., Langevin, S.A., Bowen, R.A., Panella, N.A., Biggerstaff, B.J., Miller, B.R. & Komar, N. (2004) Differential virulence of West Nile strains for American crows. *Emerg. Inf. Dis.* 10, 2161-2168
6. Davis, M.R., Langan, J.N., Johnson, Y.J., Ritchie, B.W. & Van Bonn, W. (2008) West Nile virus seroconversions after vaccination with a killed virus vaccine or a DNA vaccine. *J. Zoo Wildl. Med* 39, 582-589.
7. Docherty, D.E., Long, R.R., Griffin, K.M. & Saito, E.K. (2004) Corvidae feather pulp and West Nile virus detection. *Emerg. Inf. Dis.* 10: 907-909
8. Fitzgerald, S.D., Patterson, J.S., Kiupel, M., Simmons, H.A., Grimes, S.D., Sarver, C.F., Fulton, R.M., Steficek, B.A., Cooley, T.M., Massey, J.P. and Sikarskie, J.G. (2003) Clinical and pathologic features of West Nile virus infection in native North American owls (Family Strigidae). *Av. Dis.* 47: 602-610
9. Gubler, D.J., Petersen, L.R., Roehrig, J.T., Campbell, G.L., Komar, N., Nasci, R.S., Zielinski-Gutierrez, E., Marfin, A.A., Lanciotti, R.S., Bunning, M.L., O'Leary, D.R., Fernandez, M., Dieterich, L., Tuttle, B.B. and Deavours, R.L. (2003) Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control 3<sup>rd</sup> Revision. Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector-Borne Infectious Diseases, Fort Collins, Colorado.
10. Hubalek, Z. and Halouzka, J. (1999) West Nile Fever – a reemerging mosquito-borne viral disease in Europe. *Emerg. Inf. Dis.* 5: 643-650
11. Jiménez-Clavero MA, Sotelo E, Fernandez-Pinero J, Llorente F, Blanco JM, Rodriguez-Ramos J, Perez-Ramirez E, Höfle U. (2008) West Nile Virus in golden eagles in Spain. *Emerg. Inf. Dis.* 14, 1489-1491.
12. Kauffman, E.B., Jones, S.A., Dupuis II, A.P., Ngo, K.A., Bernard, K.A. & Kramer, L.D. (2003) Virus detection protocols for West Nile virus in vertebrate and mosquito specimens. *J. Clin. Microbiol.* 41: 3661-3667
13. Malkinson, M. & Banet, C. (2002) The role of birds in the ecology of West Nile virus in Europe and Africa. *Curr. Topics Microbiol. Immunol.* 267 Japanese Encephalitis and West Nile Viruses: 309-322
14. McLean, R.G., Ubico, S.R., Bourne, D. & Komar, N. (2002) West Nile virus in livestock and wildlife. *Curr. Topic Microbiol. Immunol.* 267 Japanese Encephalitis and West Nile Viruses: 271-308
15. Monath, T.P. and Heinz, F.X. (1996) Flaviviruses. *IN: Fields, B.N., Knipe, D.M. & Howley, P.M. (Eds.) Fields Virology.* Lippincott - Raven Publishers, Philadelphia, USA. Pp961-1034.
16. Murgue, B., Zeller, H. & Deubel, V. (2002) The ecology and epidemiology of West Nile virus in Africa, Europe and Asia. *Curr. Topics Microbiol. Immunol.* 267 Japanese Encephalitis and West Nile Viruses: 195-221
17. Nemeth, N., Gould, D., Bowen, R. & Komar, N. (2006) Natural and experimental West Nile virus infection in five raptor species. *J. Wildl. Dis* 42, 1-13.



18. Steele, K.E., Linn, M.J., Schoepp, R.J., Komar, N., Geisbert, T.W., Manduca, R.M., Calle, P.P., Raphael, B.L., Clippinger, T.L., Larsen, T., Smith, J., Lanciotti, R.S., Panella, N.A. and McNamara, T.S. (2000) Pathology of fatal West Nile virus infections in native and exotic birds during the 1999 outbreak in New York City, New York. *Vet. Pathol.* 37, 208-224
19. Turell, M.J., Bunning, M., Ludwig, G.V., Ortman, B., Chang, J., Speaker, T., Spielman, A., Mclean, R., Komar, N., Gates, R., McNamara, T., Creekmore, T., Farley, L. & Mitchell, C.J. (2003) DNA vaccine for West Nile virus infection in Fish Crows (*Corvus ossifragus*) *Emerging Infectious Diseases* 9, 1077-1081
20. Wolf, T.M., Gandolf, A.R., Dooley, J.L., Atkinson, M.W. & Wolfe, B.A. (2008) Serologic response to West Nile virus vaccination in the greater one-horned rhinoceros (*Rhinoceros unicornis*). *J Zoo Wildl. Med* 39, 537-541
21. Wunschmann, A., Shivers, J., Bender, J., Carroll, L., Fuller, S., Saggese, M., van Wettere, A. & Redig, P. (2004) Pathologic findings in red-tailed hawks (*Buteo jamaicensis*) and Cooper's hawks (*Accipiter cooperi*) naturally infected with West Nile virus. *Av. Dis.* 48: 570-580