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Declaration of Conformity

EUROIMMUN Medizinische Labordiagnostika AG
Seekamp 31, D-23560 Lübeck, Germany

declare under our sole responsibility that the ELISA products

Anti-West Nile Virus ELISA (IgG)	*EI 2662-9601 G*
Anti-West Nile Virus ELISA (IgM)	*EI 2662-9601 M*
Avidity: Anti-West Nile Virus ELISA (IgG)	*EI 2662-9601-1 G*

(product name, order no)

meet the demands of

Directive 98/79/EC on in vitro diagnostic medical devices of 27 October 1998 and its transpositions in national laws which apply to it.

Conformity assessment procedure: Annex III

Lübeck, 13.10.2016
(Place and date of issue)

Susanne Aleksandrowicz
- Member of the Board -

Dr. Wolfgang Schlumberger
- Member of the Board -

Anti-West Nile Virus ELISA (IgG)
Test instruction

ORDER NO.	ANTIBODIES AGAINST	IG CLASS	SUBSTRATE	FORMAT
EI 2662-9601 G	West Nile virus	IgG	Ag-coated microplate wells	96 x 01 (96)

Principle of the test: The ELISA test kit provides a semiquantitative or quantitative in vitro assay for human antibodies of the IgG class against West Nile virus in serum or plasma. The test kit contains microtiter strips each with 8 break-off reagent wells coated with West Nile virus antigens. In the first reaction step, diluted patient samples are incubated in the wells. In the case of positive samples, specific IgG (also IgA and IgM) antibodies will bind to the antigens. To detect the bound antibodies, a second incubation is carried out using an enzyme-labelled anti-human IgG (enzyme conjugate) catalysing a colour reaction.

Contents of the test kit:

Component	Colour	Format	Symbol
1. Microplate wells coated with antigens: 12 microplate strips each containing 8 individual break-off wells in a frame, ready for use	---	12 x 8	STRIPS
2. Calibrator 1 200 RU/ml (IgG, human), ready for use	dark red	1 x 2.0 ml	CAL1
3. Calibrator 2 20 RU/ml (IgG, human), ready for use	red	1 x 2.0 ml	CAL2
4. Calibrator 3 2 RU/ml, (IgG, human), ready for use	light red	1 x 2.0 ml	CAL3
5. Positive control (IgG, human), ready for use	blue	1 x 2.0 ml	POS CONTROL
6. Negative control (IgG, human), ready for use	green	1 x 2.0 ml	NEG CONTROL
7. Enzyme conjugate peroxidase-labelled anti-human IgG (rabbit), ready for use	green	1 x 12 ml	CONJUGATE
8. Sample buffer ready for use	light blue	1 x 100 ml	SAMPLE BUFFER
9. Wash buffer 10x concentrate	colourless	1 x 100 ml	WASH BUFFER 10x
10. Chromogen/substrate solution TMB/H_2O_2, ready for use	colourless	1 x 12 ml	SUBSTRATE
11. Stop solution 0.5 M sulphuric acid, ready for use	colourless	1 x 12 ml	STOP SOLUTION
12. Test instruction	---	1 booklet	
13. Quality control certificate	---	1 protocol	
14. Protective foil	---	2 pieces	

LOT Lot description
IVD In vitro diagnostics
CE
Storage temperature
Unopened usable until

Storage and stability: The test kit has to be stored at a temperature between +2°C to +8°C. Do not freeze. Unopened, all test kit components are stable until the indicated expiry date.

Waste disposal: Patient samples, calibrators, controls and incubated microplate strips should be handled as infectious waste. All reagents must be disposed of in accordance with local disposal regulations.

Preparation and stability of the reagents

Note: All reagents must be brought to room temperature (+18°C to +25°C) approx. 30 minutes before use. After first use, the reagents are stable until the indicated expiry date if stored at +2°C to +8°C and protected from contamination, unless stated otherwise below.
The thermostat adjusted ELISA incubator must be set at 37°C +/- 1°C.

- **Coated wells:** Ready for use. Tear open the resealable protective wrapping of the microplate at the recesses above the grip seam. Do not open until the microplate has reached room temperature to prevent the individual strips from moistening. Immediately replace the remaining wells of a partly used microplate in the protective wrapping and tightly seal with the integrated grip seam (Do not remove the desiccant bag).
  Once the protective wrapping has been opened for the first time, the wells coated with antigens can be stored in a dry place and at a temperature between +2°C and +8°C for 4 months.

- **Calibrators and controls:** Ready for use. The reagents must be mixed thoroughly before use.

- **Enzyme conjugate:** Ready for use. The enzyme conjugate must be mixed thoroughly before use.

- **Sample buffer:** Ready for use.

- **Wash buffer:** The wash buffer is a 10x concentrate. If crystallisation occurs in the concentrated buffer, warm it to 37°C and mix well before diluting. The quantity required should be removed from the bottle using a clean pipette and diluted with deionized or distilled water (1 part reagent plus 9 parts distilled water).
  For example: For 1 microplate strip, 5 ml concentrate plus 45 ml water.
  The working strength diluted wash buffer is stable for 4 weeks when stored at +2°C to +8°C and handled properly.

- **Chromogen/substrate solution:** Ready for use. Close the bottle immediately after use, as the contents are sensitive to light. The chromogen/substrate solution must be clear on use. Do not use the solution if it is blue coloured.

- **Stop solution:** Ready for use.

Warning: The controls used have been tested negative for HBsAg, anti-HCV, anti-HIV-1 and anti-HIV-2 using enzyme immunoassays and indirect immunofluorescence methods. Nonetheless, all materials should be treated as being a potential infection hazard and should be handled with care. Some of the reagents contain the toxic agent sodium azide. Avoid skin contact.

Preparation and stability of the patient samples

Samples: Human serum or EDTA, heparin or citrate plasma.

Stability: Patient samples to be investigated can generally be stored at +2°C to +8°C for up to 14 days. Diluted samples should be incubated within one working day.

Sample dilution: Patient samples are diluted **1:101** in sample buffer. For example: dilute 10 µl serum in 1.0 ml sample buffer and mix well by vortexing (sample pipettes are not suitable for mixing).

NOTE: Calibrators and controls are prediluted and ready for use, do not dilute them.

Incubation

For **semiquantative analysis** incubate **calibrator 2** along with the positive and negative controls and patient samples. For **quantitative analysis** incubate **calibrators 1, 2 and 3** along with the positive and negative controls and patient samples.

(Partly) manual test performance

Sample incubation: (1st step)
Transfer 100 µl of the calibrator, positive and negative controls or diluted patient samples into the individual microplate wells according to the pipetting protocol.
For manual processing of microplate wells, cover the finished test plate with the protective foil. When using an automated microplate processor for incubation, follow the instrument manufacturer's recommendations with regard to microwell plate sealing.
Incubate **60 minutes at 37°C ± 1°C**.

Washing:
Manual: Remove the protective foil and empty the wells and subsequently wash 3 times using 300 µl of working strength wash buffer for each wash.
Automatic: Remove the protective foil and empty the wells and subsequently wash 3 times with 450 µl of working strength wash buffer (program setting: e.g. TECAN Columbus Washer "Overflow Modus").

Leave the wash buffer in each well for 30 to 60 seconds per washing cycle, then empty the wells. After washing (manual and automated tests), thoroughly dispose of all liquid from the microplate by tapping it on absorbent paper with the openings facing downwards to remove all residual wash buffer.

Note: Residual liquid (> 10 µl) in the reagent wells after washing can interfere with the substrate and lead to false low extinction values. Insufficient washing (e.g., less than 3 wash cycles, too small wash buffer volumes, or too short reaction times) can lead to false high extinction values.
Free positions on the microplate strip should be filled with blank wells of the same plate format as that of the parameter to be investigated.

Conjugate incubation: (2nd step)
Pipette 100 µl of enzyme conjugate (peroxidase-labelled anti-human IgG) into each of the microplate wells.
When using an automated microplate processor for incubation, follow the instrument manufacturer´s recommendations with regard to microwell plate sealing.
Incubate **30 minutes at room temperature (+18°C to +25°C)**

Washing:
Empty the wells. Wash as described above.

Substrate incubation: (3rd step)
Pipette 100 µl of chromogen/substrate solution into each of the microplate wells. Incubate for **15 minutes at room temperature** (+18°C to +25°C) (protect from direct sunlight).

Stopping the reaction:
Pipette 100 µl of stop solution into each of the microplate wells in the same order and at the same speed as the chromogen/substrate solution was introduced.

Measurement:
Photometric measurement of the colour intensity should be made at a wavelength of 450 nm and a reference wavelength between 620 nm and 650 nm **within 30 minutes of adding the stop solution.** Prior to measuring, slightly shake the microplate to ensure a homogeneous distribution of the solution.

Test performance using fully automated analysis devices

Sample dilution and test performance are carried out fully automatically using the analysis device. The incubation conditions programmed in the respective software authorised by EUROIMMUN may deviate slightly from the specifications given in the ELISA test instruction. However, these conditions were validated in respect of the combination of the EUROIMMUN Analyzer I, Analyzer I-2P or the DSX from Dynex and this EUROIMMUN ELISA. Validation documents are available on inquiry. Automated test performance using other fully automated, open system analysis devices is possible, however, the combination should be validated by the user.

Pipetting protocol

	1	2	3	4	5	6	7	8	9	10	11	12
A	**C 2**	**P 6**	**P 14**	**P 22**			**C 1**	**P 4**	**P 12**	**P 20**		
B	**pos.**	**P 7**	**P 15**	**P 23**			**C 2**	**P 5**	**P 13**	**P 21**		
C	**neg.**	**P 8**	**P 16**	**P 24**			**C 3**	**P 6**	**P 14**	**P 22**		
D	**P 1**	**P 9**	**P 17**				**pos.**	**P 7**	**P 15**	**P 23**		
E	**P 2**	**P 10**	**P 18**				**neg.**	**P 8**	**P 16**	**P 24**		
F	**P 3**	**P 11**	**P 19**				**P 1**	**P 9**	**P 17**			
G	**P 4**	**P 12**	**P 20**				**P 2**	**P 10**	**P 18**			
H	**P 5**	**P 13**	**P 21**				**P 3**	**P 11**	**P 19**			

The pipetting protocol for microtiter strips 1-4 is an example for the **semiquantitative analysis** of 24 patient samples (P 1 to P 24).
The pipetting protocol for microtiter strips 7-10 is an example for the **quantitative analysis** of 24 patient samples (P 1 to P 24).

The calibrators (C 1 to C 3), the positive (pos.) and negative (neg.) controls, and the patient samples have each been incubated in one well. The reliability of the ELISA test can be improved by duplicate determinations for each sample.
The wells can be broken off individually from the strips. This makes it possible to adjust the number of test substrates used to the number of samples to be examined and minimizes reagent wastage.
Both positive and negative controls serve as internal controls for the reliability of the test procedure. They should be assayed with each test run.

Calculation of results

Semiquantitative: Results can be evaluated semiquantitatively by calculating a ratio of the extinction value of the control or patient sample over the extinction value of the calibrator 2. Calculate the ratio according the following formula:

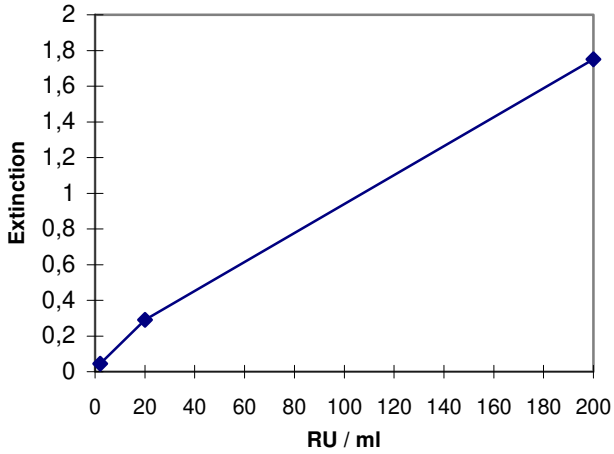
$$\frac{\textbf{Extinction of the control or patient sample}}{\textbf{Extinction of calibrator 2}} = \textbf{Ratio}$$

EUROIMMUN recommends interpreting results as follows:

Ratio <0.8:	**negative**
Ratio ≥0.8 to <1.1:	**borderline**
Ratio ≥1.1:	**positive**

In cases of borderline test results, an additional patient sample should be taken 7 days later and re-tested in parallel with the first patient sample. The results of both samples allow proper evaluation of titer changes.

Quantitative: The standard curve from which the concentration of antibodies in the patient samples can be taken is obtained by point-to-point plotting of the extinction values measured for the 3 calibration sera against the corresponding units (linear/linear). Use “point-to-point” plotting for calculation of the standard curve by computer. The following plot is an example of a typical calibration curve. Please do not use this curve for the determination of antibody concentrations in patient samples.



If the extinction of a serum sample lies above the value of calibrator 1 (200 RU/ml). The result should be given as “>200 RU/ml“. It is recommended that the sample be re-tested at a dilution of 1:400. The result in RU/ml read from the calibration curve for this sample must then be multiplied by a factor of 4.

The upper limit of the normal range of non-infected persons (**cut-off value**) recommended by EUROIMMUN is **20 relative units (RU)/ml**. EUROIMMUN recommends interpreting results as follows:

<16 RU/ml:	**negative**
≥16 to <22 RU/ml:	**borderline**
≥22 RU/ml:	**positive**

Evaluation information: For duplicate determinations the mean of the two values should be taken. If the two values deviate substantially from one another the sample should be retested.

For the interpretation of borderline results an investigation using further tests (e.g. avidity determination of antibody class IgG) can be helpful. Diagnosis can be secured by the determination of the titer change in two serum samples taken at an interval of at least 7 days and analysed in parallel.

For diagnosis, the clinical symptoms of the patient should always be taken into account along with the serological results.

Test characteristics

Calibration: As no quantificated international reference serum exists for antibodies against West Nile virus, the calibration is performed in relative units (RU).

For every group of tests performed, the extinction values of the calibrators and the relative units and/or ratios determined for the positive and negative controls must lie within the limits stated for the relevant test kit lot. A quality control certificate containing these reference values is included. If the values specified for the controls are not achieved, the test results may be inaccurate and the test should be repeated.
The activity of the enzyme used is temperature-dependent and the extinction values may vary if a thermostat is not used. The higher the room temperature during substrate incubation, the greater will be the extinction values. Corresponding variations apply also to the incubation times. However, the calibration sera are subject to the same influences, with the result that such variations will be largely compensated in the calculation of the result.

Antigen: The antigen source is a recombinant, detergent-extracted glycoprotein E of WNV from the membrane fraction of human cells.

Linearity: The linearity of the Anti-West Nile Virus ELISA (IgG) was determined by assaying 4 serial dilutions of different patient samples. The coefficient of determination R^2 for all sera was > 0.95. The Anti-West Nile Virus ELISA (IgG) is linear at least in the tested concentration range (10 RU/ml to 160 RU/ml).

Detection limit: The lower detection limit is defined as the mean value of an analyte-free samples plus three times the standard deviation and is the smallest detectable antibody titer. The lower detection limit of the Anti-West Nile Virus ELISA (IgG) is 0.4 RU/ml.

Cross reactivity: Cross reactivities to other flaviviruses cannot be excluded. They were recognized with anti-TBE positive and anti-Dengue virus positive samples.

Antibodies against	n	Anti-West Nile Virus ELISA (IgG)
Adenovirus	12	0%
Chlamydia pneumoniae	12	0%
CMV	12	0%
EBV-CA	12	0%
Helicobacter pylori	12	0%
HSV-1	12	0%
Influenza virus A	12	0%
Influenza virus B	12	0%
Measles virus	12	0%
Mumps virus	12	0%
Mycoplasma pneumoniae	12	0%
Parainfluenza virus Pool	12	0%
RSV	12	0%
Rubella virus	12	0%
Toxoplasma gondii	9	0%
VZV	12	0%

Interference: Haemolytic, lipaemic and icteric samples showed no influence on the result up to a concentration of 10 mg/ml for haemoglobin, 20 mg/ml for triglycerides and 0.4 mg/ml for bilirubin in this ELISA.

Reproducibility: The reproducibility of the test was investigated by determining the intra- and inter-assay coefficients of variation using 3 sera. The intra-assay CVs are based on 20 determinations and the inter-assay CVs on 4 determinations performed in 6 different test runs.

Intra-assay variation, n = 20		
Serum	**Mean value (RU/ml)**	**CV (%)**
1	101	6.1
2	104	3.3
3	149	2.7

Inter-assay variation, n = 4 x 6		
Serum	**Mean value (RU/ml)**	**CV (%)**
1	103	5.1
2	120	4.9
3	171	4.2

Sensitivity and specificity: Samples from 295 patients (origin: Europe) were investgated using the EUROIMMUN Anti-West Nile Virus ELISA and a neutralization test (NT) (performed by RKI, Berlin) as a reference method. The specificity was 96.9%, with a sensitivity of 99.5%. Values for 4 of the samples were borderline and were not included in the calculation.

Reference range: The levels of anti-West Nile virus antibodies (IgG) were analyzed with this EUROIMMUN ELISA in a panel of 500 healthy blood donors. With a cut-off of 20 RU/ml, 1.0% of the blood donors were anti-West Nile virus positive (IgG).

Clinical significance

West Nile virus (WNV) is an enveloped single-stranded RNA virus of the Flaviviridae family [1]. This family comprises around 100 virus types that are presently categorized into the three known species Flavivirus, Pestivirus and Hepacivirus [1, 2, 3, 4, 5]. West Nile virus received its name in 1937 when it was first isolated from a blood sample of an elderly woman living in the West Nile district in Uganda, who had fever of unknown cause accompanied by neurological disorders [6]. Further isolates were achieved only in 1951 from the sera of children with weak, unspecific symptoms, namely in Egypt where the virus is endemically distributed. At that time mice and embryonated hen's eggs were used for virus detection [1].

WNV is present not only in tropical areas, but also in moderate climate regions [2, 3, 4, 5]. Significant epidemics were observed in 1951/52 and 1957 in Israel and 1974 and 1983/84 in South Africa [1]. In the mid 90's the virus changed its virulence causing an epidemic accumulation of WNV encephalitis in Algeria (1994), Rumania (1996/97), the Czech Republic (1997), the Democratic Republic of Congo (1998), Russia, North America (1999) and Israel (2000) [2, 3, 7, 8, 9, 10, 11, 12].

In the USA 149 infections with 18 cases of death were recorded from 1999 to 2001. In 2002 this number rose to 4156 infections and 284 deaths, in 2003 to 9858 infections and 262 deaths [7, 8, 10]. Currently the virus has been detected in seven Canadian provinces, in 48 USA states and in Mexico, as well as in Puerto Rico, the Dominican Republic, Jamaica, Guadeloupe and El Salvador [3, 9, 11].

Since 1958, when antibodies against the WNV were first detected in the sera of two Albanians, repeated outbreaks of West Nile fever have occurred in Southern and Eastern Europe and meanwhile also in Central and West Europe [8, 9, 10, 12, 14, 15]. Its emergence and rapid spread is credited to world climate change, long-distance travel and globalization of economic trade [9, 12, 13, 15, 16, 17]. Consequent monitoring of West Nile activity by controlling sera of exposed persons is essential [15, 17, 18, 19]. Seroprevalence studies in endemic regions have shown an infection spread of up to 40% [14]. West Nile virus is therefore the Flavivirus with the largest distribution area [2, 3, 4, 5, 9].

WNV is transmitted by a number of mosquitoes. In the Mediterranean region and in Africa mosquitoes of the Culex univittatus complex species are the main arthropod hosts, while in North America WNV could be detected in 37 mosquito species, with Culex pipiens being the main vector [1, 2, 3, 4, 7, 9]. In India Culex vishnui and in France Culex modestus were identified as the main vectors [1]. In total WNV could be found in more than 40 mosquito and in several tick species [3, 4, 5].

Birds represent the vertebrate reservoir [1, 20, 21]. Alone in the USA WNV has been found in more than 162 species of birds. Many of them showed clinical symptoms and thousands of birds died after contracting a natural infection [7, 8, 10, 20, 21]. Birds that survive develop lifelong immunity. Acting as coincidental hosts mammals can also become infected when bitten by an infected mosquito [10, 13, 14]. Transmission has additionally been documented via breast milk, bone marrow transplantations, liver and heart transplants, blood transfusions, lab accidents such as open wounds during handling of infected brain tissue as well as transplacental transmission [2, 3, 4, 5, 8, 22, 23, 24, 25, 26, 27, 28]. Other than humans, mostly only horses became ill after an infection [2, 13, 21]. As well as WNV infection via a mosquito bite, a second natural infection source is possible in animals, namely via feeding on infected prey [3, 5]. An experimental infection of cats was successfully achieved by feeding them infected mice [20, 21].

70% to 80% of the humans infected with WNV showed no symptoms [8]. In the remaining 20%-30%, signs of sudden flu-like symptoms appear after an incubation period of 2-6 days with fever ranging from 38.5 to 40°C lasting for 3-5 days, nausea, shivering, head and back aches, joint and muscle pain and other unspecific symptoms such as loss of appetite, dizziness, vomiting, diarrhoea, coughing and a sore throat [1, 2, 3, 4, 5].

Typical for epidemical occurring fever are exanthema on the breast, back and upper extremities and general lymph node swelling [1, 3, 26]. Severe clinical cases of WNV infections are characterized by myocarditis, pancreatitis and hepatitis and since 1996, also neurological disorders, as WNV is now capable of crossing the blood-brain barrier [3]. The neurological symptoms begin after a short febrile prodome phase approximately 1-7 days after infection and become manifest in the form of encephalitis and meningoencephalitis accompanied by stiffness, spasms and shivering as the result of damage done to the basal ganglia [3, 8, 29, 30].

Another widespread symptom is general muscle weakness similar to the Guillain-Barré syndrome and also polio-like paralysis [29, 30]. Approximately 4%-14% of the hospitalized patient cases are fatal [29]. High risk factors are old age and a weak immune system [1, 3, 29].

An infection with WNV during pregnancy can cause miscarriages, congenital meningitis, birth defects in approx. 10% of the cases and in an additional 10% of newborns growth disturbances [3, 8, 27, 28].

The diagnosis of WNV can be performed by virus detection or by detection of specific antibodies [1, 4, 17, 18, 19]. As virus isolation from serum or cerebrospinal fluid or virus detection using Real-Time Reverse Transcription-Polymerase Chain Reaction (RT-PCR) is usually unsuccessful due to short viraemia and low virus titers, the detection of specific WNV antibodies using ELISA and IFA has gained importance [11, 17, 18, 19, 31, 32, 33, 34, 35, 36, 37, 38].

Specific IgM antibodies in serum can be determined using ELISA or IIFT [19]. Antibodies of class IgM are detectable in serum from the second day after initial symptoms of the illness occur. A four-fold increase in titer of the respective class of antibody is considered proof of a WNV infection.

If the IgM test is negative, even though the symptoms indicate a WNV infection, a second serum sample should be taken and tested for IgM antibodies a few days later. A combination of ELISA and IIFT provides close to 100% reliability [17, 18, 31, 32, 33, 34]. Anti-WNV IgM antibodies persist for 2 to 3 months, often for more than a year [4, 17, 18, 19, 22].

Antibodies of class IgG are detectable approx. 2 days after the appearance of IgM antibodies [11, 19, 32, 33, 34, 40]. Two to four weeks after a positive IgM result the infection can be confirmed and its severity and prognosis evaluated using a qualitative and quantitative test for the detection of specific WNV IgG antibodies in the patient serum [34].

For the reliable differentiation between acute and past infections the detection of low-avidity IgG antibodies gives evidence for a primary or an acute WNV infection, while high-avidity antibodies indicate a past or reactivated WNV infection [39, 40, 41]. EUROIMMUN offers additional test systems for determination of IgG avidity in both ELISA and IIFT formats. The detection of low-avidity antibodies using ELISA and IIFT in parallel is possible for WNV as it is for Toxoplasma gondii, rubella virus, EBV-EA, EBV-CA and Corona virus [39, 40, 41].

As the degree of similarity within the Flavivirus family is high antibody cross reactions can occur [19, 31, 42]. Therefore samples that are positive for specific IgM and/or IgG antibodies against WNV should be titrated and investigated on all relevant Flavivirus IIFT substrates for cross reactions. By comparing the titer strengths the initial result can be confirmed or disproved by the second detection and an infection with another Flavivirus identified as the source of illness [17, 32, 34].

To supplement and extend the current Anti-West Nile Virus ELISA and Anti-West Nile Virus IIFT (each IgG or IgM or avidity) BIOCHIP Mosaics and Profiles for the detection (IIFT) of infections with Flaviviruses and the BIOCHIP Mosaic Fever Profile 1: South-East Asia have been developed. With these tests specific antibodies (IgG and IgM) against several infectious agents can be investigated simultaneously [36, 37, 38, 43, 44, 45]. These supplementary tests allow similar or ambiguous disease symptoms and potential cross reactions to be clarified and differential diagnostic issues to be addressed [1].

A specific antiviral therapy for WNV encephalitis is not available at present [1, 2, 3, 4, 5, 14, 35]. Intensive medical care is the only possibility to positively influence the illness. Eradication of WNV is impossible due to the natural bird-mosquito cycle [1]. A vaccine with formalin inactivated WNV is only available for horses [2, 10]. Therefore public education, individual precautionary measures and protection against insect bites are essential contributions to preventing WNV infections [2, 3, 4, 5, 14, 16].

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Anti-West Nile Virus ELISA (IgM)
Test instruction

ORDER NO.	ANTIBODIES AGAINST	IG CLASS	SUBSTRATE	FORMAT
EI 2662-9601 M	West Nile Virus	IgM	Ag-coated microplate wells	96 x 01 (96)

Principle of the test: The ELISA test kit provides a semiquantitative in vitro assay for human antibodies of the IgM class against West Nile virus in serum or plasma. The test kit contains microtiter strips each with 8 break-off reagent wells coated with West Nile virus antigens. In the first reaction step, diluted patient samples are incubated in the wells. In the case of positive samples, specific IgM (also IgA and IgG) antibodies will bind to the antigens. To detect the bound antibodies, a second incubation is carried out using an enzyme-labelled anti-human IgM (enzyme conjugate) catalysing a colour reaction.

Contents of the test kit:

Component	Colour	Format	Symbol
1. Microplate wells coated with antigens: 12 microplate strips each containing 8 individual break-off wells in a frame, ready for use	---	12 x 8	STRIPS
2. Calibrator (IgM, human), ready for use	dark red	1 x 2.0 ml	CAL
3. Positive control (IgM, human), ready for use	blue	1 x 2.0 ml	POS CONTROL
4. Negative control (IgM, human), ready for use	green	1 x 2.0 ml	NEG CONTROL
5. Enzyme conjugate peroxidase-labelled anti-human IgM (goat), ready for use	red	1 x 12 ml	CONJUGATE
6. Sample buffer buffer containing IgG/RF-Absorbent (Anti-human IgG antibody preparation obtained from goat), ready for use	green	1 x 100 ml	SAMPLE BUFFER
7. Wash buffer 10x concentrate	colourless	1 x 100 ml	WASH BUFFER 10x
8. Chromogen/substrate solution TMB/H_2O_2, ready for use	colourless	1 x 12 ml	SUBSTRATE
9. Stop solution 0.5 M sulphuric acid, ready for use	colourless	1 x 12 ml	STOP SOLUTION
10. Test instruction	---	1 booklet	
11. Quality control certificate	---	1 protocol	
12. Protective foil	---	3 pieces	
LOT Lot description IVD In vitro diagnostics	CE	Storage temperature Unopened usable until	

Storage and stability: The test kit has to be stored at a temperature between +2°C to +8°C. Do not freeze. Unopened, all test kit components are stable until the indicated expiry date.

Waste disposal: Patient samples, calibrators, controls and incubated microplate strips should be handled as infectious waste. All reagents must be disposed of in accordance with local disposal regulations.

Preparation and stability of the reagents

Note: All reagents must be brought to room temperature (+18°C to +25°C) approx. 30 minutes before use. After first use, the reagents are stable until the indicated expiry date if stored at +2°C to +8°C and protected from contamination, unless stated otherwise below.
The thermostat adjusted ELISA incubator must be set at 37°C +/- 1°C.

- **Coated wells:** Ready for use. Tear open the resealable protective wrapping of the microplate at the recesses above the grip seam. Do not open until the microplate has reached room temperature to prevent the individual strips from moistening. Immediately replace the remaining wells of a partly used microplate in the protective wrapping and tightly seal with the integrated grip seam (Do not remove the desiccant bag).
  Once the protective wrapping has been opened for the first time, the wells coated with antigens can be stored in a dry place and at a temperature between +2°C and +8°C for 4 months.

- **Calibrator and controls:** Ready for use. The reagents must be mixed thoroughly before use.

- **Enzyme conjugate:** Ready for use. The enzyme conjugate must be mixed thoroughly before use.

- **Sample buffer:** Ready for use. The green coloured sample buffer contains IgG/RF absorbent. Serum or plasma samples diluted with this sample buffer are only to be used for the determination of IgM antibodies.

- **Wash buffer:** The wash buffer is a 10x concentrate. If crystallization occurs in the concentrated buffer, warm it to 37°C and mix well before diluting. The quantity required should be removed from the bottle using a clean pipette and diluted with deionized or distilled water (1 part reagent plus 9 parts distilled water).
  For example: For 1 microplate strip, 5 ml concentrate plus 45 ml water.
  The working strength diluted wash buffer is stable for 4 weeks when stored at +2°C to +8°C and handled properly.

- **Chromogen/substrate solution:** Ready for use. Close the bottle immediately after use, as the contents are sensitive to light. The chromogen/substrate solution must be clear on use. Do not use the solution if it is blue coloured.

- **Stop solution:** Ready for use.

Warning: The control sera used have been tested negative for HBsAg, anti-HCV, anti-HIV-1 and anti-HIV-2 using enzyme immunoassays and indirect immunofluorescence methods. Nonetheless, all materials should be treated as being a potential infection hazard and should be handled with care. Some of the reagents contain the toxic agent sodium azide. Avoid skin contact.

Preparation and stability of the patient samples

Samples: Human serum or EDTA, heparin or citrate plasma.

Stability: Patient samples to be investigated can generally be stored at +2°C to +8°C for up to 14 days. Diluted samples should be incubated within one working day.

Introduction: Before the determination of specific antibodies of class IgM, antibodies of class IgG should be removed from the patient sample. This procedure must be carried out in order to prevent any rheumatoid factors from reacting with specifically bound IgG, which would lead to false positive IgM test results, and to prevent specific IgG displacing IgM from the antigen, which would lead to false IgM negative test results.

Functional principle: The sample buffer (green coloured!) contains an anti-human antibody preparation from goat. IgG from a serum sample is bound with high specificity by these antibodies and precipitated. If the sample also contains rheumatoid factors, these will be absorbed by the IgG/anti-human IgG complex.

Separation properties:
- All IgG subclasses are bound and precipitated by the anti-human IgG antibodies.
- Human serum IgG in concentrations of up to 15 mg per ml are removed (average serum IgG concentration in adults: 12 mg per ml).
- Rheumatoid factors are also removed.
- The recovery rate of the IgM fraction is almost 100%.

Performance: The **patient samples** for analysis are diluted **1:101** with sample buffer. For example, add 10 µl serum to 1.0 ml sample buffer and mix well. Incubate the mixture for at least **10 minutes** at room temperature. Subsequently, it can be pipetted into the microplate wells according to the pipetting protocol.

Notes:
- Antibodies of the class IgG should not be analyzed with this mixture.
- It is possible to check the efficacy of the IgG/RF absorbent for an individual patient sample by performing an IgG test in parallel to the IgM test using the mixture. If the IgG test is negative, the IgM result can be considered as reliable.
- The calibrator and controls containing IgM antibodies are pre-diluted and ready for use, do not dilute them.

Incubation

(Partly) manual test performance

Sample incubation: (1st step)
Transfer 100 µl of the calibrator, positive and negative controls or diluted patient samples into the individual microplate wells according to the pipetting protocol.
For manual processing of microplate wells, cover the finished test plate with the protective foil. When using an automated microplate processor for incubation, follow the instrument manufacturer´s recommendations with regard to microwell plate sealing.
Incubate **60 minutes at 37°C ± 1°C**.

Washing:
Manual: Remove the protective foil and empty the wells and subsequently wash 3 times using 300 µl of working strength wash buffer for each wash.
Automatic: Remove the protective foil and empty the wells and subsequently wash 3 times with 450 µl of working strength wash buffer (program setting: e.g. TECAN Columbus Washer "Overflow Modus").

Leave the wash buffer in each well for 30 to 60 seconds per washing cycle, then empty the wells. After washing (manual and automated tests), thoroughly dispose of all liquid from the microplate by tapping it on absorbent paper with the openings facing downwards to remove all residual wash buffer.

Note: Residual liquid (> 10 µl) in the reagent wells after washing can interfere with the substrate and lead to false low extinction values. Insufficient washing (e.g., less than 3 wash cycles, too small wash buffer volumes, or too short reaction times) can lead to false high extinction values.
Free positions on the microplate strip should be filled with blank wells of the same plate format as that of the parameter to be investigated.

Conjugate incubation: (2nd step)
Pipette 100 µl of enzyme conjugate (peroxidase-labelled anti-human IgM) into each of the microplate wells.
When using an automated microplate processor for incubation, follow the instrument manufacturer´s recommendations with regard to microwell plate sealing.
Incubate **30 minutes at room temperature (+18°C to +25°C)**.

Washing:
Empty the wells. Wash as described above.

Substrate incubation: (3. step)
Pipette 100 µl of chromogen/substrate solution into each of the microplate wells. Incubate for **15 minutes at room temperature** (+18°C to +25°C) (protect from direct sunlight).

Stopping the reaction: (3rd step)
Pipette 100 µl of stop solution into each of the microplate wells in the same order and at the same speed as the chromogen/substrate solution was introduced.

Measurement:
Photometric measurement of the colour intensity should be made at a wavelength of 450 nm and a reference wavelength between 620 nm and 650 nm **within 30 minutes of adding the stop solution.** Prior to measuring, slightly shake the microplate to ensure a homogeneous distribution of the solution.

Test performance using fully automated analysis devices

Sample dilution and test performance are carried out fully automatically using the analysis device. The incubation conditions programmed in the respective software authorised by EUROIMMUN may deviate slightly from the specifications given in the ELISA test instruction. However, these conditions were validated in respect of the combination of the Analyzer I, Analyzer I-2P and the DSX from Dynex and this EUROIMMUN ELISA. Validation documents are available on inquiry. Automated test performance using other fully automated, open system analysis devices is possible, however, the combination should be validated by the user.

Pipetting protocol

	1	2	3	4	5	6	7	8	9	10	11	12
A	**C**	**P 6**	**P 14**	**P 22**								
B	**pos.**	**P 7**	**P 15**	**P 23**								
C	**neg.**	**P 8**	**P 16**	**P 24**								
D	**P 1**	**P 9**	**P 17**									
E	**P 2**	**P 10**	**P 18**									
F	**P 3**	**P 11**	**P 19**									
G	**P 4**	**P 12**	**P 20**									
H	**P 5**	**P 13**	**P 21**									

The above pipetting protocol is an example of the **semiquantitative analysis** of antibodies in 24 patient samples (P 1 to P 24).

Calibrator (C), positive (pos.) and negative (neg.) control as well as the patient samples have been incubated in one well each. The reliability of the ELISA test can be improved by duplicate determinations of each sample.
The wells can be broken off individually from the strips. This makes it possible to adjust the number of test substrates used to the number of samples to be examined and minimizes reagent wastage.
Both positive and negative controls serve as internal controls for the reliability of the test procedure. They should be assayed with each test run.

Calculation of results

The extinction value of the calibrator defines the upper limit of the reference range of non-infected persons (**cut-off**) recommended by EUROIMMUN. Values above the indicated cut-off are to be considered as positive, those below as negative.

Semiquantitative: Results can be evaluated semiquantitatively by calculating a ratio of the extinction value of the control or patient sample over the extinction value of calibrator. Use the following formula to calculate the ratio:

$$\frac{\textbf{Extinction of the control/patient sample}}{\textbf{Extinction of calibrators}} = \textbf{Ratio}$$

EUROIMMUN recommends interpreting results as follows:

Ratio <0.8: **negative**
Ratio ≥0.8 to <1.1: **borderline**
Ratio ≥1.1: **positive**

Evaluation information: For duplicate determinations the mean of the two values should be taken. If the two values deviate substantially from one another the sample should be retested.

For the interpretation of borderline results an investigation using further tests (e.g. avidity determination of antibody class IgG) can be helpful. Diagnosis can be secured by the determination of the titer change in two serum samples taken at an interval of at least 7 days and analysed in parallel.

For diagnosis, the clinical symptoms of the patient should always be taken into account along with the serological results.

Test characteristics

Calibration: As no quantificated international reference serum exists for antibodies of the IgM class against West Nile virus, results are provided in the form of ratios which are a relative measure for the concentration of antibodies.

For every group of tests performed, the extinction values of the calibrators and the ratios determined for the positive and negative controls must lie within the limits stated for the relevant test kit lot. A quality control certificate containing these reference values is included. If the values specified for the control sera are not achieved, the test results may be inaccurate and the test should be repeated.

The activity of the enzyme used is temperature-dependent and the extinction values may vary if a thermostat is not used. The higher the room temperature during substrate incubation, the greater will be the extinction values. Corresponding variations apply also to the incubation times. However, the calibrators are subject to the same influences, with the result that such variations will be largely compensated in the calculation of the result.

Antigen: The antigen source is a recombinant, detergent-extracted glycoprotein E of WNV from the membrane fraction of human cells.

Detection limit: The lower detection limit is defined as the mean value of an analyte-free sample plus three times the standard deviation and is the smallest detectable antibody titer. The lower detection limit of the Anti-West Nile ELISA (IgM) is a ratio value of 0.03.

Cross reactivity: Cross reactivities to other flaviviruses cannot be excluded. They were recognized with anti-TBE positive and anti-Dengue virus positive samples.

Antibodies against	n	Anti-West Nile ELISA (IgM)
Borrelia burgdoferi	9	0%
CMV	8	0%
EBV-CA	9	0%
HSV-1/2	2	0%
Measles virus	10	0%
Mumps virus	9	0%
Parvovirus B19	8	0%
Rubella virus	10	0%
Toxoplasma gondii	10	0%
VZV	4	0%

Interference: Haemolytic, lipaemic and icteric samples showed no influence on the result up to a concentration of 10 mg/ml for haemoglobin, 20 mg/ml for triglycerides and 0.4 mg/ml for bilirubin in this ELISA.

Reproducibility: The reproducibility of the test was investigated by determining the intra- and inter-assay coefficients of variation using 3 sera. The intra-assay CVs are based on 20 determinations and the inter-assay CVs on 4 determinations performed in 6 different test runs.

Intra-assay variation, n = 20		
Serum	**Mean value (Ratio)**	**CV (%)**
1	1.9	5.9
2	2.0	2.2
3	2.4	4.0

***Inter-assay variation,* n = 4 x 6**		
Serum	**Mean value (Ratio)**	**CV (%)**
1	1.9	3.9
2	2.1	9.4
3	2.4	6.8

Sensitivity and specificity: Study I: For the determination of the sensitivity 18 clinically and serologically precharacterised sera (Robert Koch Institute, Berlin, Germany) were tested with the EUROIMMUN Anti-West Nile Virus ELISA (IgM). The sensitivity amounted to 94.4%.

Study II: 99 patient sera, characterised as positive at the Saskatchewan Disease Control Laboratory (Canada) using several serological methods, were investigated with the EUROIMMUN Anti-West Nile Virus ELISA (IgM). The sensitivity was 93.7%. For the determination of the specificity 500 blood donor samples were investigated. The specificity was 99.8%.

Reference range: The levels of anti-West Nile virus antibodies (IgM) were analyzed with this EUROIMMUN ELISA in a panel of 500 healthy blood donors. With a cut-off ratio of 1.0, 0.2% of the blood donors were anti-West Nile virus positive (IgM).

Clinical significance

West Nile virus (WNV) is an enveloped single-stranded RNA virus of the Flaviviridae family [1]. This family comprises around 100 virus types that are presently categorized into the three known species Flavivirus, Pestivirus and Hepacivirus [1, 2, 3, 4, 5]. West Nile virus received its name in 1937 when it was first isolated from a blood sample of an elderly woman living in the West Nile district in Uganda, who had fever of unknown cause accompanied by neurological disorders [6]. Further isolates were achieved only in 1951 from the sera of children with weak, unspecific symptoms, namely in Egypt where the virus is endemically distributed. At that time mice and embryonated hen's eggs were used for virus detection [1].

WNV is present not only in tropical areas, but also in moderate climate regions [2, 3, 4, 5]. Significant epidemics were observed in 1951/52 and 1957 in Israel and 1974 and 1983/84 in South Africa [1]. In the mid 90's the virus changed its virulence causing an epidemic accumulation of WNV encephalitis in Algeria (1994), Rumania (1996/97), the Czech Republic (1997), the Democratic Republic of Congo (1998), Russia, North America (1999) and Israel (2000) [2, 3, 7, 8, 9, 10, 11, 12]. In the USA 149 infections with 18 cases of death were recorded from 1999 to 2001. In 2002 this number rose to 4156 infections and 284 deaths, in 2003 to 9858 infections and 262 deaths [7, 8, 10]. Currently the virus has been detected in seven Canadian provinces, in 48 USA states and in Mexico, as well as in Puerto Rico, the Dominican Republic, Jamaica, Guadeloupe and El Salvador [3, 9, 11].

Since 1958, when antibodies against the WNV were first detected in the sera of two Albanians, repeated outbreaks of West Nile fever have occurred in Southern and Eastern Europe and meanwhile also in Central and West Europe [8, 9, 10, 12, 14, 15]. Its emergence and rapid spread is credited to world climate change, long-distance travel and globalization of economic trade [9, 12, 13, 15, 16, 17]. Consequent monitoring of West Nile activity by controlling sera of exposed persons is essential [15, 17, 18, 19]. Seroprevalence studies in endemic regions have shown an infection spread of up to 40% [14]. West Nile virus is therefore the Flavivirus with the largest distribution area [2, 3, 4, 5, 9].

WNV is transmitted by a number of mosquitoes. In the Mediterranean region and in Africa mosquitoes of the Culex univittatus complex species are the main arthropod hosts, while in North America WNV could be detected in 37 mosquito species, with Culex pipiens being the main vector [1, 2, 3, 4, 7, 9]. In India Culex vishnui and in France Culex modestus were identified as the main vectors [1]. In total WNV could be found in more than 40 mosquito and in several tick species [3, 4, 5].

Birds represent the vertebrate reservoir [1, 20, 21]. Alone in the USA WNV has been found in more than 162 species of birds. Many of them showed clinical symptoms and thousands of birds died after contracting a natural infection [7, 8, 10, 20, 21]. Birds that survive develop lifelong immunity. Acting as coincidental hosts mammals can also become infected when bitten by an infected mosquito [10, 13, 14]. Transmission has additionally been documented via breast milk, bone marrow transplantations, liver and heart transplants, blood transfusions, lab accidents such as open wounds during handling of infected brain tissue as well as transplacental transmission [2, 3, 4, 5, 8, 22, 23, 24, 25, 26, 27, 28]. Other than humans, mostly only horses became ill after an infection [2, 13, 21]. As well as WNV infection via a mosquito bite, a second natural infection source is possible in animals, namely via feeding on infected prey [3, 5]. An experimental infection of cats was successfully achieved by feeding them infected mice [20, 21].

70% to 80% of the humans infected with WNV showed no symptoms [8]. In the remaining 20%-30%, signs of sudden flu-like symptoms appear after an incubation period of 2-6 days with fever ranging from 38.5 to 40°C lasting for 3-5 days, nausea, shivering, head and back aches, joint and muscle pain and other unspecific symptoms such as loss of appetite, dizziness, vomiting, diarrhoea, coughing and a sore throat [1, 2, 3, 4, 5].

Typical for epidemical occurring fever are exanthema on the breast, back and upper extremities and general lymph node swelling [1, 3, 26]. Severe clinical cases of WNV infections are characterized by myocarditis, pancreatitis and hepatitis and since 1996, also neurological disorders, as WNV is now capable of crossing the blood-brain barrier [3]. The neurological symptoms begin after a short febrile prodome phase approximately 1-7 days after infection and become manifest in the form of encephalitis and meningoencephalitis accompanied by stiffness, spasms and shivering as the result of damage done to the basal ganglia [3, 8, 29, 30].

Another widespread symptom is general muscle weakness similar to the Guillain-Barré syndrome and also polio-like paralysis [29, 30]. Approximately 4%-14% of the hospitalized patient cases are fatal [29]. High risk factors are old age and a weak immune system [1, 3, 29].

An infection with WNV during pregnancy can cause miscarriages, congenital meningitis, birth defects in approx. 10% of the cases and in an additional 10% of newborns growth disturbances [3, 8, 27, 28].

The diagnosis of WNV can be performed by virus detection or by detection of specific antibodies [1, 4, 17, 18, 19]. As virus isolation from serum or cerebrospinal fluid or virus detection using Real-Time Reverse Transcription-Polymerase Chain Reaction (RT-PCR) is usually unsuccessful due to short viraemia and low virus titers, the detection of specific WNV antibodies using ELISA and IFA has gained importance [11, 17, 18, 19, 31, 32, 33, 34, 35, 36, 37, 38].

Specific IgM antibodies in serum can be determined using ELISA or IIFT [19]. Antibodies of class IgM are detectable in serum from the second day after initial symptoms of the illness occur. A four-fold increase in titer of the respective class of antibody is considered proof of a WNV infection.

If the IgM test is negative, even though the symptoms indicate a WNV infection, a second serum sample should be taken and tested for IgM antibodies a few days later. A combination of ELISA and IIFT provides close to 100% reliability [17, 18, 31, 32, 33, 34]. Anti-WNV IgM antibodies persist for 2 to 3 months, often for more than a year [4, 17, 18, 19, 22].

Antibodies of class IgG are detectable approx. 2 days after the appearance of IgM antibodies [11, 19, 32, 33, 34, 40]. Two to four weeks after a positive IgM result the infection can be confirmed and its severity and prognosis evaluated using a qualitative and quantitative test for the detection of specific WNV IgG antibodies in the patient serum [34].

For the reliable differentiation between acute and past infections the detection of low-avidity IgG antibodies gives evidence for a primary or an acute WNV infection, while high-avidity antibodies indicate a past or reactivated WNV infection [39, 40, 41].

EUROIMMUN offers additional test systems for determination of IgG avidity in both ELISA and IIFT formats. The detection of low-avidity antibodies using ELISA and IIFT in parallel is possible for WNV as it is for Toxoplasma gondii, rubella virus, EBV-EA, EBV-CA and Corona virus [39, 40, 41].

As the degree of similarity within the Flavivirus family is high antibody cross reactions can occur [19, 31, 42]. Therefore samples that are positive for specific IgM and/or IgG antibodies against WNV should be titrated and investigated on all relevant Flavivirus IIFT substrates for cross reactions. By comparing the titer strengths the initial result can be confirmed or disproved by the second detection and an infection with another Flavivirus identified as the source of illness [17, 32, 34].

To supplement and extend the current Anti-West Nile Virus ELISA and Anti-West Nile Virus IIFT (each IgG or IgM or avidity) BIOCHIP Mosaics and Profiles for the detection (IIFT) of infections with Flaviviruses and the BIOCHIP Mosaic Fever Profile 1: South-East Asia have been developed. With these tests specific antibodies (IgG and IgM) against several infectious agents can be investigated simultaneously [36, 37, 38, 43, 44, 45]. These supplementary tests allow similar or ambiguous disease symptoms and potential cross reactions to be clarified and differential diagnostic issues to be addressed [1].

A specific antiviral therapy for WNV encephalitis is not available at present [1, 2, 3, 4, 5, 14, 35]. Intensive medical care is the only possibility to positively influence the illness. Eradication of WNV is impossible due to the natural bird-mosquito cycle [1]. A vaccine with formalin inactivated WNV is only available for horses [2, 10]. Therefore public education, individual precautionary measures and protection against insect bites are essential contributions to preventing WNV infections [2, 3, 4, 5, 14, 16].

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