Ad hoc Group on the Revision of Chapters on Japanese encephalitis of the *Terrestrial Animal Health Code*

Original: English (EN)
Paris

19 – 21 November 2024

Table of Contents

List of Annexes

World Organisation for Animal Health
Founded as OIE

Standards Department
standards.dept@woah.org

12, rue de Prony
75017 Paris, France

T. +33 (0)1 44 15 18 88
F. +33 (0)1 42 67 09 87
woah@woah.org
www.woah.org

The WOAH *ad hoc* Group on the revision of the chapter on Japanese encephalitis of the *Terrestrial Code* (hereafter the Group) met in-person from 19 to 21 November 2024 at the WOAH headquarters in Paris following the recommendations from the WOAH *Terrestrial Animal Health Standards Commission* and the *Scientific Commission for Animal Diseases* (hereafter the WOAH Specialist Commissions) to revise the current *Terrestrial Code* Chapter 8.10. on Japanese encephalitis.

1. Opening

Dr Montserrat Arroyo, WOAH Deputy Director General for International Standards and Science, thanked the experts and their supporting institutions for their commitment and support to the work of the Group. She thanked the Group for their confidentiality and invited them to consider representing their respective regions. Dr Arroyo emphasised the importance of establishing implementable standards and workable provisions grounded in clear rationale, while also advocating for a One Health approach to address potential zoonotic aspects. Finally, she encouraged Group members to propose relevant recommendations to the *Terrestrial Code and Manual for Diagnostic Tests and Vaccines (Terrestrial Manual)* chapters on Japanese encephalitis and equine encephalitides.

Dr Monal Daptardar from the Science Department presented the disease listing criteria (*Terrestrial Code* Chapter 1.2) and the assessment results of Japanese encephalitis against those criteria. Dr Mauro Meske from the Status Department provided a brief overview of the Terms of Reference (ToR) and the meeting of the Group and introduced the Secretariat supporting the Group's work.

2. Appointment of the Chair and Rapporteur

Dr Tania Ware was appointed as chair and Dr Natalia Cernicchiaro acted as rapporteur with collaboration from WOAH Secretariat. The ToR and list of participants are provided as Annexes 1 and 2, respectively.

3. Revision of Chapter 8.10. Infection with Japanese encephalitis virus

3.1. Initial considerations

The Group reviewed the remarks of the WOAH Specialist Commissions on the revision of chapters on equine encephalitides of the *Terrestrial Code*, and the recommendations of the *ad hoc* Group on Eastern and Western Equine Encephalomyelitis (EEE and WEE). The current Chapter 8.10. on Japanese Encephalitis (JE) was noted to be limited, outdated, and inconsistent with the conventions for disease-specific chapters in the *Terrestrial Code* disease-specific chapters. Discrepancies were identified between the provisions in *Terrestrial Code* Chapter 8.10 (last updated in 2000) and Chapter 3.1.10 of the *Terrestrial Manual* (last updated in 2021). The Group agreed to draft a completely new Chapter 8.10. and include provisions following the framework for *Terrestrial Code* Standards.

The Group emphasised that the revised chapter would primarily focus on animal health while addressing the zoonotic nature of JE and the role of animals in transmitting the Japanese encephalitis virus (JEV). Recommendations would aim to mitigate risks to both animal and public health, aligning with the Specialist Commissions' conclusions on maintaining JE as a notifiable disease due to its public health implications. Considering the extensive changes to be introduced, the Group agreed to propose a completely new draft chapter that would replace the current Chapter 8.10.

In order to specify the vectors of infection with JEV, the Group agreed to use the term 'culicine mosquito' as it covers the whole range of currently known competent vectors for JEV, according to the *Terrestrial Manual* and other papers (Oliveira et al., 2018; Auerswald et al., 2021; Mulvey et al., 2021; van den Hurk et al., 2022).

3.2. General provisions (Article 8.10.1.)

a) Definition of the disease:

The Group discussed renaming the *Terrestrial Code* Chapter 8.10. and in the *Terrestrial Manual* Chapter 3.1.10. to "*Infection with Orthoflavivirus japonicum* (Japanese Encephalitis)" per ICTV taxonomy (EC54, Online meeting, July 2022), but ultimately retained the name "*Infection with* Japanese Encephalitis Virus (JEV)" due to global recognition and potential confusion from a name change. Coordination with WHO would be required for any nomenclature adjustments.

b) *Animal Hosts*

The Group agreed that suids (amplifying hosts), equids (dead-end hosts), and wild birds (primary reservoir and amplifying hosts) were the key animal hosts for JEV for the purposes of the *Terrestrial Code*. Equids, though dead-end hosts, were noted for their potential use as sentinel species for monitoring outbreaks affecting pigs and humans. The Group acknowledged that there is documented evidence of JEV findings in other species such as bats, dogs, cattle, alpacas, etc., however, there is no evidence that these species play an important role in the transmission of the disease (Oliveira et al., 2017; Park et al., 2022; Levesque et al., 2024; Moore et al., 2024). Therefore, they should not be included in the case definition. The Group suggested to include these other species in the *Terrestrial Manual* as susceptible species.

Wild birds were highlighted as critical for transmission dynamics, and the generic term "wild birds" was preferred over "water birds" to cover the various species involved. Poultry were excluded as there is only experimental evidence of their ability to experience high viraemia, but no evidence of transmission in natural conditions. It was agreed that the role of poultry would be addressed in the provisions for surveillance in other species, as they are important components in surveillance efforts for disease detection and control. Although a study conducted on wild birds explained that most of the observed birds were waterfowl (Yang et al., 2011; Moore et al., 2024), the Group suggested to use the generic term "wild birds" instead of "water birds" in this Chapter. While domestic birds are not a major concern in this context, transmission dynamics in wild birds are significant, as they could involve various species (Nemeth et al., 2012; Moore et al., 2024). Therefore, it is important to keep the term general, as several species of wild birds could potentially be involved in transmission. Due to public health importance, the Group recommended to keep wild birds in the case definition as there is a need to inform the public health authorities if a case of infection with JEV is detected in these species.

c) *Definition of the occurrence of the disease*

The Group agreed to include the isolation of JEV as a standalone method to define a case, and to include the detection of nucleic acid, antigen or antibodies when they are associated with other supporting evidence, such as clinical signs, pathological lesions or an epidemiological link to a confirmed JE case. The Group agreed to not to include “giving suspicion of previous association or contact with JEV” as supporting evidence, as done in other chapters of the *Terrestrial Code*, because there was no clear definition of its meaning in the *Terrestrial Code,* and that would be specifically vague for this disease, for which most cases would be asymptomatic.

The Group also agreed to include a specific point to define the occurrence of JE by the sole detection of seroconversion, as, in pigs, seroconversion can be detected even in the absence of clinical signs. The Group observed that several countries use evidence of seroconversion for JEV to determine the presence of the disease but advised that this should be complemented with epidemiological data and ensure that seroconversion specific to JEV is not related to vaccination, as there are no DIVA vaccines.

The Group recommended the Biological Standards Commission to review the *Terrestrial Manual* Chapter 3.1.10. to include new molecular tests for the diagnosis of JEV.

d) *Incubation period and infective period*

The Group agreed that for the purposes of the chapter, as described in the following sections of this report, there was only a need to define these periods for suids, given the role of this species in the transmission of the virus and their relevance to considerations in the Chapter under review.

The Group proposed to refer to ‘*infective period*’ rather than ‘incubation period’. The definition of *incubation period* in the glossary of the *Terrestrial Code* would not be accurate for JEV as most suids do not show clinical signs. The Group also considered that there is currently insufficient evidence to define a standard duration of the incubation period in this species. The Group agreed to define the infective period as of seven days, based on the longest documented viraemia (Ladreyt et al., 2019; Park et al., 2022), given the significance of viremia as an indicator of active viral infection and its critical role in facilitating mosquito-borne virus transmission.

3.3. Safety commodities

The Group considered equid and suid commodities that are generally traded and assessed if they complied with the criteria in Chapter 2.2. The Group considered that it was not relevant to discuss the trade implications of 'wild birds' as the concerned species would not be of interest for international trade.

a) Equid commodities

The Group concluded that equids are dead-end hosts and there is sufficient evidence to substantiate that the risk of transmission from live equids or any derived product to other animal and human hosts is negligible (Oliveira et al., 2017; Levesque et al., 2024; Moore et al., 2024). In addition, the Group concluded that there is no evidence of transmission of the pathogen through products derived from equids. Thus, the Group agreed that live equids and their products should be considered as safe commodities and be included in the list of safe commodities as Article 8.10.2.

b) Suid commodities

- Live Suids

As suids are considered amplifying hosts for infection with JEV, the Group agreed that live suids should be considered to be a commodity that can transmit JEV to other animals, and that live suids should be subjected to specific risk mitigation measures if they are to be traded (See item 3.5. of this report).

- Meat and meat products from suids

The Group acknowledged that JEV is unlikely to survive outside live hosts, and that evidence demonstrates that there is no risk of transmission of JEV through meat from suids to other animals or to humans. Thus, the Group agreed that meat and meat products from suids can be considered as a safe commodity, provided that the meat comes from an authorised abattoir where ante- and post-mortem meat inspection were conducted with favourable results as per Chapter 6.3. of the *Terrestrial Code*. The Group agreed to include them in the list of safe commodities as Article 8.10.2

- Animal products from suids

For the same reason as mentioned above, the Group concluded that the by-products of suids, such as protein meal, rendered fat, gelatine and collagen, and other products from suids, such as hides, skins and hair, can be considered as safe commodities as well. The Group agreed to include them in the list of safe commodities as Article 8.10.2

- Germinal products from suids

The Group noted that there is experimental evidence that semen can transmit JEV, but this has not been demonstrated in natural conditions. The Group also discussed papers that demonstrated evidence for transmission from infected pigs shedding virus in semen, but only under experimental conditions (Habu et al., 1977; Ogasa et al., 1977; Teng et al., 2013). The Group concluded that evidence of semen transmission has been documented, and therefore, this product cannot be considered as a safe commodity. Nevertheless, the Group considered that there is insufficient evidence of natural transmission of JEV through suid semen as to provide standardised recommended measures for importation of semen from infected countries. The Group recommended that Members should consider potential sanitary measures for international trade of semen through a risk analysis in compliance with Chapter 2.1 of the *Terrestrial Code*, and that additional specific provisions could be added to this chapter at a future revision if further evidence becomes available.

Concerning other germinal products, the Group noted that, although vertical transmission is documented, there is no documented evidence of the risk of transmission of the JEV via embryos. However, taking into consideration that embryos of suids are not largely commercialised, the Group agreed not to address them in the chapter at this moment.

The Group also recommended the Biological Standards Commissions to include some recommendations in this regard in Chapter 3.1.10. of the *Terrestrial Manual*.

3.4. Provisions on Animal health status

3.4.1. Country or zone free from infection with JEV (Article 8.10.3.)

The Group agreed that historical freedom provisions in Article 1.4.6. of the *Terrestrial Code* would apply for this disease but noted that the disease would have to be notifiable for at least the past two years, considering the seasonality and life cycle of mosquitoes and wild bird reservoirs. This is consistent when compared to provisions in Chapters for similar diseases (i.e., WNV Chapter).

The Group highlighted that the primary goal of JEV surveillance is to mitigate animal and public health risks, support suid production, and enable safe international trade. The Group agreed that freedom from JEV can be demonstrated for domestic and captive wild suids and equids, but would be difficult for feral and wild animals.

The Group agreed that, to demonstrate freedom from JEV, vaccination must not have occurred within the last 12 months, as distinguishing vaccinated from infected animals is not possible with the current vaccines. Vaccination, while reducing viremia and morbidity, complicates disease status verification. The Group noted that detection of JEV in other species such as dogs and cattle should trigger targeted surveillance in primary hosts.

3.4.2. Compartment free from infection with JEV

The Group considered that a compartment could be established and that free compartments could be useful in particular circumstances (pharmaceutical industry and medical facilities or establishments testing animals or high value stocks). The Group agreed that the establishment of compartments for JEV could be applicable, however, they emphasised that certain factors should be considered including the large range of wild reservoirs for JEV and that continuous vector protection and biosecurity measures should be in place in a compartment established in an infected area.

3.4.3. Recovery of free status

The Group acknowledged that recovery of free status after an outbreak would be particularly challenging when competent vectors are present in the area. The Group concluded that if an outbreak occurs in a previously JEV-free country, the provisions for country or zone free from infection with JEV above would apply.

3.5. Provisions for international trade

3.5.1. Recommendations for importation of live suids from countries, zones or compartments free from infection with JEV

The Group concluded that importing live suids from JEV-free countries, zones or compartments poses no risk of JEV introduction. The Group recommended that veterinary authorities request an international veterinary certificate attesting that suids were kept since birth or at least 14 days before shipment - double the length of the maximum infective period - in such areas. If pigs originated from an infected area prior to 14 days before shipment, the 14-day safety margin would ensure they are no longer capable of transmitting the virus.

The Group emphasised that, if suids transit through infected zones, they should be transported in mosquito-protected conditions, with this requirement documented in the health certificate.

3.5.2. Recommendations for importation of live suids from countries or zones infected with JEV

The Group agreed to include different alternatives to import suids from infected countries or zones safely.

First, the Group agreed that vaccination of pigs efficiently protects pigs from infection.

The Group agreed that neutralising antibodies in vaccinated suids can be detected starting 6 days after vaccination (Imoto et al., 2010; García-Nicolas et al., 2017; O'Brien et al, 2024), and that requesting serological tests to detect antibodies prior to shipment would not be useful in vaccinated suids as there are no DIVA vaccines available yet.

Therefore, the Group considered that the imported suids should have been vaccinated against JEV, and vaccination had been completed according to the manufacture recommendation at least 21 days (to enable sufficient time for seroconversion after completion of vaccination regimen) and no longer than one year prior to shipment, and they should not show clinical signs on the day of shipment.

Secondly, the Group also agreed that suids could also be imported safely if held for at least 14 days (twice the length of the maximum duration of the infective period) before shipment in a vector-protected quarantine station in an area with low mosquito activity. During transport to the shipment location, suids must remain protected from mosquito bites. This 14-day quarantine ensures that any infected suids would clear the virus during this period, preventing JEV transmission.

3.6. Protecting suids from culicine mosquito bites

Noting described in the previous points, the Group agreed to make general recommendations for protecting suids from mosquito bites in establishments and during transportation. Insecticide use was recommended for containers and vehicles, not directly applied to livestock, due to residual effects.

The Group highlighted that equids were excluded from these provisions, as they are dead-end hosts for JEV.

3.7. Surveillance

The Group emphasised that the aim of the surveillance for JEV is mainly to support measures to mitigate animal and public health risks (as per EEE and WEE recently drafted Code Chapter), and secondarily to ensure safe international trade of animal commodities.

The Group considered that awareness campaigns should be conducted, targeting relevant stakeholders, including industry, as they are largely involved in implementing surveillance activities, as well as those in contact with wildlife, animal keepers, and personnel from slaughterhouses.

The Group noted that surveillance for JEV should cover equids, suids and wild birds. The Group recommended to include clinical and syndromic surveillance as important components of an early warning system for equids and suids. The Group acknowledged that although most of the JEV infections are asymptomatic and there are not pathognomonic signs, suspected cases could be identified through detection of the occurrence of unusual mortalities or suid reproductive or litter abnormalities (syndromic surveillance). The Group also noted that surveillance should also consider findings in incidental hosts, such as dogs, goats, and cattle, which could indicate the presence of infection in primary hosts.

The Group noted that tonsils could be a useful sample (García-Nicolas et al., 2017; Mulvey et al., 2021; Chapagain et al., 2022; Park et al., 2022; Redant et al., 2022;O'Brien et al., 2024), as for other diseases (i.e., classical swine fever), and requested that the BSC considered to include in the corresponding chapter of the *Terrestrial Manual* the use of oronasal fluids and tonsils (Ricklin et al., 2016;García-Nicolas et al., 2017; Lyons et al., 2018; Chapagain et al., 2022).

The Group acknowledged that environmental surveillance could provide valuable information, and that samples from livestock and abattoir wastewater, effluent ponds and fresh water, could be considered (Ahmed et al., 2024; Liu et al., 2024).

Mosquito populations can be monitored for the presence of JEV through the collection of adult mosquitoes or larvae, providing an early warning system of viral activity and information on ecological conditions favourable for mosquito breeding in a certain area. Environmental surveillance strategies are especially useful in areas with high pig densities or ongoing outbreaks.

4. Recommendations to update WOAH Terrestrial Manual Chapter 3.1.10

As noted in several of the points above, while reviewing the *Terrestrial Code* chapter and the reference materials, the Group identified the possible need for updating Chapter 3.1.10 of the *Terrestrial Manual*. In summary, the Group recommended that the Biological Standards Commission addresses the following items (also included in this report)

1. **Assess the need to rename the Chapter**

    - Consider if it would be convenient renaming it to align with the ICTV taxonomy, "Infection with Orthoflavivirus japonicum (Japanese Encephalitis)," while retaining the current name for global recognition.

2. **Update Key Animal Hosts**:

    - Include a comprehensive list of suids (amplifying hosts), equids (dead-end hosts), and wild birds (primary reservoirs and amplifying hosts).

    - Add susceptible species such as bats, dogs, and cattle, among others, as recommended for surveillance purposes, even though they are not epidemiologically significant in disease transmission.

    - Use the term "wild birds" rather than "water birds" to encompass a broader range of species.

3. **Diagnostic Criteria**:

    - Add new molecular diagnostic methods, including updated nucleic acid detection tests for JEV diagnosis.

4. **Infective Period Definition**:

    - Define the infective period for suids as seven days based on documented viraemia duration.

5. **Surveillance**:

    - Add provisions for environmental surveillance in water sources, including abattoir wastewater and effluent ponds, to monitor mosquito populations and viral presence.

    - Include recommendations for using oronasal fluids and tonsils for sample collection, as tonsils are being used successfully in diagnostics for other diseases.

5. Recommendations for future revision of Terrestrial Code chapters on West Nile Fever (WNF) and VEE

The Group proposed aligning WNF Chapters with the JEV Chapter, including removing seasonality freedom requirements and treating equids and their products as safe commodities. In addition, WNF should not focus only on geese and ducks.

The Group recommended that the *Biological Standards Commission* assesses the incubation and infected periods for these diseases (VEE and WNF) and update the corresponding chapters of the *Terrestrial Manual* accordingly before convening an *ad hoc* Group to revise these Code Chapters.

The Group also supported the recommendations of the EEE and WEE *ad hoc* Group that Biological Standards Commission should consider the feasibility of identification and differentiation of the (endemic-epizootic) strains of VEE.

6. Next steps

The Group's report and draft Chapter 8.10 will be considered by the WOAH Specialist Commissions at their February 2025 meetings.

…/Appendixes

Annex 1. Terms of reference

MEETING OF THE AD HOC GROUP ON THE REVISION OF CHAPTERS

ON JAPANESE ENCEPHALITIS OF THE TERRESTRIAL ANIMAL HEALTH CODE

PARIS, 19- 21 NOVEMBER 2024

_____

Purpose

The purpose of the *ad hoc* Group on the Revision of the *Terrestrial Code*. Chapter 8.10. Japanese encephalitis.

Background

The Terrestrial Animal Health Standards Commission (the Code Commission) considered requests from Members to review Chapters 8.10. Japanese encephalitis (JEE) and 12.11. Venezuelan Equine Encephalomyelitis (VEE), which were raised during the 89th General Session in May 2022, and several considerations presented by the Secretariat, including the impact on trade for the movement of horses from infected countries, the discrepancies observed between the chapters of the *Terrestrial Code* and *Terrestrial Manual*, as well as the opinion of the International Horse Sports Confederation (IHSC) and discussions of the Scientific Commission at its September 2015 meeting.

The Code Commission noted that Chapter 8.10. was first adopted in 1992, and the most recent update was adopted in 2000, but the corresponding *Terrestrial Manual* Chapter 3.1.10. was updated in 2021. It also agreed that the current Chapter 8.10. was partly obsolete, given the latest information in Chapter 3.1.10. on Japanese encephalitis of the *Terrestrial Manual*.

The Code Commission also noted that the revisions of Chapter 12.4. Equine encephalomyelitis (Eastern and Western) (EEE and WEE) (no update since its first adoption in 1968) and Chapter 12.11. Venezuelan equine encephalomyelitis (the most recent update adopted in 1998) was included in its work programme in February 2020, but that work had not yet been initiated. Considering the epidemiological similarities across these three diseases, the Code Commission agreed to approach the revisions of these three disease-specific chapters together to ensure a consistent logic is applied to all three chapters. It also agreed that Chapter 8.21. West Nile fever (WNF) should also be considered, even if updated more recently.

The Code Commission requested to first undertake a scientific assessment of the susceptible animals, their epidemiological role and their relevance for surveillance and disease prevention and control. The assessment of these diseases against the criteria for the inclusion of diseases, infections and infestations in the WOAH list of notifiable terrestrial animal diseases in accordance with Chapter 1.2. of the *Terrestrial Code*, was conducted by subject matter experts, and considered by the Scientific Commission at its meeting of September 2023.

At its February 2024 meeting, the Code Commission agreed to revise *Terrestrial Code* chapters on equine encephalitides, and an *ad hoc* Group was convened in June 2024. At the meeting, the Group drafted a revised Chapter 12.4. (Eastern and western equine encephalitis) and provided further guidance for the revision of the Chapters 8.10. and 12.11. The Group recommended that, considering the differences in terms of animal hosts and epidemiology, a dedicated *ad hoc* Group be convened to undertake the revision of *Terrestrial Code* Chapters 8.10. Japanese encephalitis.

At the Code Commission September meeting, the Code Commission considered the report of the Group and agreed to proceed with the revision of *Terrestrial Code* Chapters 8.10. Japanese encephalitis, following the abovementioned recommendations.

Considerations

When developing this work, the *ad hoc* Group should consider:

1. the general structure and content of the *Terrestrial Code*, in particular the guidance provided in the *Framework for Terrestrial Code standards* (disease-specific chapters);
2. the use of Glossary definitions in the *Terrestrial Code*;
3. previous opinions of WOAH Specialist Commissions' and the *ad hoc* Group on equine encephalitides.
4. the current Chapters 3.1.10. (JEE) of the *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*;
5. all working documents provided by the WOAH Secretariat.

Expectations

Ad hoc Group members should:

- be familiar with the structure of the *Terrestrial Code* and the use of Glossary definitions and the *Framework for Terrestrial Code standards*;
- have read and considered the current Chapter 8.10. of the *Terrestrial Code*;
- have read all working documents provided by the WOAH Secretariat;
- contribute to discussions, and;
- contribute to drafting text for the revised chapter and the meeting report.
- be familiar with the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary measures (especially Article 8 and Annex C), the WTO Agreement on Trade Facilitation, the Codex Alimentarius Principles for Food Import and Export Inspection and Certification (CAC/GL 20-1995) Guidelines for the Design, Operation, Assessment and Accreditation of Food Import and Export Certification Systems (CAC/GL 26-1997) (to be provided in the Working Documents); and any other relevant international standards.

(Only for new members) *Ad hoc* Group members should:

- sign the WOAH Undertaking on Confidentiality;
- complete the WOAH Declaration of Interest form, and;
- read and acknowledge the WOAH personal data management policy.

Deliverables

1. a report presenting the rationale for decisions and proposed texts and supporting references when relevant.
2. the draft revised *Terrestrial Code* chapter on Japanese encephalitis.
3. any recommendations that, from the revision of this chapter, may be useful to complete the revision of other chapters on equine encephalitides.
4. any points that require guidance from the Code Commission for the next steps in the development of the revised draft chapter.

Reporting / timeline

The work of this *ad hoc* Group will likely be completed within one meeting but could require follow up meetings and may meet virtually or in person according to the needs. After a meeting, the Group should finalise the relevant deliverables within 5 weeks after the completion of the meeting.

Annex 2. List of Participants

MEETING OF THE AD HOC GROUP ON THE REVISION OF CHAPTER ON JAPANESE ENCEPHALITIS OF THE TERRESTRIAL ANIMAL HEALTH CODE

PARIS, 19–21 NOVEMBER 2024

MEMBERS

Dr Tania Ware
Senior Veterinary Officer
Department of Agriculture, Fisheries and Forestry,
Animal Biosecurity Branch
AUSTRALIA

Dr Natalia Cernicchiaro
Associate Director of Research
Center for Outcomes Research and Epidemiology
Kansas State University
UNITED STATES OF AMERICA

Dr Gaëlle Gonzalez
Deputy Director
EU Ref Lab for equine diseases
ANSES
FRANCE

Dr Kirsty Richards
Manager Industry and Government Liaison
SunPork Group
AUSTRALIA

Dr Dong-Kun Yang
Animal and Plant Quarantine Agency
WOAH Reference Laboratory for Japanese encephalitis
KOREA (REP. OF)

WOAH HEADQUARTERS

Dr Akinobu Kawamura
Scientific Officer
Standards Department

Dr Francisco D'Alessio
Deputy Head
Standards Department

Dr Monal Daptardar
Scientific Coordinator
Science Department

Dr Mauro Meske
Senior Status Officer
Status Department

Annex 3. References:

Auerswald, H., Maquart, P-O., Chevalier, V., Boyer, S. 2021. Mosquito vector competence for Japanese encephalitis virus. Viruses, 13: 1154. Doi.org/10.3390/v13061154. https://pmc.ncbi.nlm.nih.gov/articles/PMC8234777/

Oliveira, A.R.S., Cohnstaedt, L.W., Strathe, E., Etcheverry, L., McVey, D.S., Piaggio, J, Cernicchiaro, N. 2018. Meta-analysis of Japanese encephalitis virus infection, dissemination, and transmission rates in vectors. Am. J. Trop. Med. Hyg. 98(3): 883-890. doi:10.4269/ajtmh.17-0622. https://pmc.ncbi.nlm.nih.gov/articles/PMC5930895/

Van den Hurk, A.F., Skinner, E., Ritchie, S.A., Mackenzie, J.S. 2022. The emergence of Japanese encephalitis in Australia in 2022: existing knowledge of mosquito vectors. Viruses, 14:1208. Doi.org/10.3390/v14061208. https://pmc.ncbi.nlm.nih.gov/articles/PMC9231386/

Mulvey, P., Duong, V., Boyer, S., Burgess, G., Williams, D.T., Horwood, P.F. (2021). The ecology and evolution of Japanese encephalitis virus. Pathogens, 10:1534. Doi.org/10.3390/pathogens10121534. https://www.mdpi.com/2076-0817/10/12/1534

Oliveira, A.R.S., Cohstaedt, L.W., Strathe, E., Hernandez, L.E., McVey, D.S., Piaggio, J., Cernicchiaro, N. 2017. Meta-analyses of the proportioni of Japanese encephalitis virus infection in vectors and vertebrate hosts. Parasites & Vectors, 10:418. Doi 10.1186/s13071-017-2354-7. https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-017-2354-7

Levesque, Z.A., Walsh, M., Webb, C., Zadoks, R., Brookes, V.J. 2024. A scoping review of evidence of naturally occurring Japanese encephalitis infection in vertebrate animals other than humans, ardeid birds and pigs. PLoS Negl Trop Dis, Oct 4;18(10):e0012510. doi: 10.1371/journal.pntd.0012510. https://pmc.ncbi.nlm.nih.gov/articles/PMC11482687/pdf/pntd.0012510.pdf

Moore, K.T., Mangan, M.J., Linnegar, B., Athni, T., McCallum, H.I., Trewin, B.J., Skinner, E. 2024. Australian vertebrate hosts of Japanese encephalitis virus; a review of the evidence. bioRxiv [Preprint], 2024 Apr 26:2024.04.23.590833. [Version 1] doi: 10.1101/2024.04.23.590833. https://pmc.ncbi.nlm.nih.gov/articles/PMC11071400/pdf/nihpp-2024.04.23.590833v1.pdf

Yang, D.K., Oh, Y.I., Kim, H.R., Lee, Y.J., Moon, O.K., Yoon, H., Kim, B., Lee, K.W., Song, J.Y. 2011. Serosurveillance for Japanese encephalitis virus in wild birds captured in Korea. J Vet Sci, Dec;12(4):373-7. doi: 10.4142/jvs.2011.12.4.373. PMID: 22122903; PMCID: PMC3232397. https://pmc.ncbi.nlm.nih.gov/articles/PMC3232397/

Nemeth, N., Bosco-Lauth, A., Oesterle, P., Kohler, D., Bowen, R. North American birds as potential amplifying hosts of Japanese encephalitis virus. Am J Trop Med Hyg. 2012 Oct;87(4):760-7. doi: 10.4269/ajtmh.2012.12-0141. Epub 2012 Aug 27. PMID: 22927494; PMCID: PMC3516332. https://pmc.ncbi.nlm.nih.gov/articles/PMC3516332/

Ladreyt, H., Durand, B., Dussart, P., Chevalier, V. 2019. How Central Is the Domestic Pig in the Epidemiological Cycle of Japanese Encephalitis Virus? A Review of Scientific Evidence and Implications for Disease Control. Viruses,Oct 15;11(10):949. doi: 10.3390/v11100949. PMID: 31618959; PMCID: PMC6832429. https://pmc.ncbi.nlm.nih.gov/articles/PMC6832429/

Park, S.L., Huang, Y.-J.S., Vanlandingham, D.L. 2022. Re-Examining the Importance of Pigs in the Transmission of Japanese Encephalitis Virus. Pathogens,11:575. https://doi.org/10.3390/ pathogens11050575. https://pubmed.ncbi.nlm.nih.gov/35631096/

Habu, A., Murakami, Y., Ogasa, A., Fujisaki, Y. 1977. Disorder of spermatogenesis and viral discharge into semen in boars infected with Japanese encephalitis virus. Uirusu. 1977 Jun;27(1):21-6. Japanese. doi: 10.2222/jsv.27.21. PMID: 203101. https://pubmed.ncbi.nlm.nih.gov/203101/

Ogasa, A., Yokoki, Y., Fujisaki, Y., and Habu, A. 1977. Reproductive disorders in boars infected experimentally with Japanese encephalitis virus. Jpn. J. Anim. Reprod. 23, 171–175. https://www.jstage.jst.go.jp/article/jrd1977/23/4/23_4_171/_article/-char/ja/

Teng, M., Luo, J., Fan, J.M., Chen, L., Wang, X.T., Yao, W., Wang, C.Q., Zhang. G.P. 2013. Molecular characterization of Japanese encephalitis viruses circulating in pigs and mosquitoes on pig farms in the Chinese province of Henan. Virus Genes, Feb;46(1):170-4. doi: 10.1007/s11262-012-0813-y. Epub 2012 Sep 4. PMID: 22945473. https://pubmed.ncbi.nlm.nih.gov/22945473/

García-Nicolás, O., Ricklin, M.E., Liniger, M., Vielle, N.J., Python, S., Souque, P., Charneau, P., Summerfield, A. 2017. A Japanese Encephalitis Virus Vaccine Inducing Antibodies Strongly Enhancing In Vitro Infection Is Protective in Pigs. Viruses, May 22;9(5):124. doi: 10.3390/v9050124. PMID: 28531165; PMCID: PMC5454436. https://pmc.ncbi.nlm.nih.gov/articles/PMC5454436/

Imoto, J.C., Ishikawa, T., Yamanaka, A., Konishi, M., Murakami, K., Shibahara, T., Kubo, M., Lim, C.K., Hamano, M., Takasaki, T., Kurane, I., Udagawa, H., Mukuta, Y., Konishi, E. 2010. Needle-free jet injection of small doses of Japanese encephalitis DNA and inactivated vaccine mixture induces neutralizing antibodies in miniature pigs and protects against fetal death and mummification in pregnant sows. Vaccine, 28 (46):7373-7380, doi.org/10.1016/j.vaccine.2010.09.008. https://www.sciencedirect.com/science/article/pii/S0264410X10013162?via%3Dihub

Redant, V., Favoreel, H.W., Dallmeier, K., Van Campe, W., De Regge, N. 2022. Japanese Encephalitis Virus Persistence in Porcine Tonsils Is Associated With a Weak Induction of the Innate Immune Response, an Absence of IFNγ mRNA Expression, and a Decreased Frequency of $CD4^{+}CD8^{+}$ Double-Positive T Cells. Front Cell Infect Microbiol, Feb 24;12:834888. doi: 10.3389/fcimb.2022.834888. PMID: 35281443; PMCID: PMC8908958. https://pubmed.ncbi.nlm.nih.gov/35281443/

Ahmed, W., Liu, Y., Smith, W., Ingall, W., Belby, M., Bivins, A., Bertsch, P., Williams, D.T., Richards, K., Simpson, S. 2024. Leveraging wastewater surveillance to detect viral diseases in livestock settings. Sci Total Environ, Jun 25;931:172593. doi: 10.1016/j.scitotenv.2024.172593. Epub 2024 Apr 18. PMID: 38642765. https://pubmed.ncbi.nlm.nih.gov/38642765/

Liu, Y., Smith, W., Gebrewold, M., Simpson, S.L., Wang, X., Ahmed, W. 2024 Development of a triplex RT-qPCR assay for simultaneous quantification of Japanese encephalitis, Murray Valley encephalitis, and West Nile viruses for environmental surveillance. Microbiol Spectr, Oct 3;12(10):e0136424. doi: 10.1128/spectrum.01364-24. Epub 2024 Aug 20. PMID: 39162492; PMCID: PMC11448262. https://pubmed.ncbi.nlm.nih.gov/39162492/

Lyons, A.C., Huang, Y.S., Park, S.L., Ayers, V.B., Hettenbach, S.M., Higgs, S., McVey, D.S., Noronha, L., Hsu, W.W., Vanlandingham, D.L. 2018. Shedding of Japanese Encephalitis Virus in Oral Fluid of Infected Swine. Vector Borne Zoonotic Dis, Sep;18(9):469-474. doi: 10.1089/vbz.2018.2283. Epub 2018 May 9. PMID: 29742002. https://pubmed.ncbi.nlm.nih.gov/29742002/

Ricklin, M.E., García-Nicolás, O., Brechbühl, D., Python, S., Zumkehr, B., Nougairede, A., Charrel, R.N., Posthaus, H., Oevermann, A., Summerfield, A. 2016. Vector-free transmission and persistence of Japanese encephalitis virus in pigs. Nat Commun, Feb 23;7:10832. doi: 10.1038/ncomms10832. PMID: 26902924; PMCID: PMC4766424. https://pubmed.ncbi.nlm.nih.gov/26902924/

Chapagain, S., Pal Singh, P., Le, K., Safronetz, D., Wood, H., Karniychuk, U. 2022. Japanese encephalitis virus persists in the human reproductive epithelium and porcine reproductive tissues. PLoS Negl Trop Dis, Jul 29;16(7):e0010656. doi: 10.1371/journal.pntd.0010656. PMID: 35905074; PMCID: PMC9337681. https://pubmed.ncbi.nlm.nih.gov/35905074/