

Renaming of the genus *Flavivirus* to *Orthoflavivirus* and extension of binomial species names within the family *Flaviviridae*

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Abstract

This review provides a summary of the recently ratified changes to genus and species nomenclature within the virus family *Flaviviridae* along with reasons for these changes. First, it was considered that the vernacular terms “flaviviral”, “flavivirus”, and “flaviviruses” could under certain circumstances be ambiguous due to the same word stem “flavi” in the taxon names *Flaviviridae* and *Flavivirus*; these terms could either have referred to all viruses classified in the family *Flaviviridae* or only to viruses classified in the included genus *Flavivirus*. To remove this ambiguity, the genus name *Flavivirus* was changed to *Orthoflavivirus* by the International Committee on Taxonomy of Viruses (ICTV). Second, all species names in the family were changed to adhere to a newly ICTV-mandated binomial format (e.g., *Orthoflavivirus zikaense*, *Hepacivirus hominis*) similar to nomenclature conventions used for species elsewhere in biology. It is important to note, however, that virus names remain unchanged. Here we outline the revised taxonomy of the family *Flaviviridae* as approved by the ICTV in April 2023.

Introduction

The family *Flaviviridae* encompasses four genera and 89 species [1]. The International Committee on Taxonomy of Viruses (ICTV) [5] recently made a number of changes to the names of genera and species in the family. This review describes these changes and the reasons for them. As a guide for those working in the flavivirus field, we also provide a comprehensive list of the previous and new nomenclature for each species and their viruses.

New genus name *Orthoflavivirus*

The genus *Flavivirus* within the family *Flaviviridae* was established for a large number of arthropod-borne viruses (e.g., dengue viruses and Zika virus) that are high-consequence human and veterinary pathogens [6]. The genus name *Flavivirus* contained the word stem “flavi”, which is also used for the family name. Therefore, the vernacular terms “flaviviral”, “flavivirus”, and “flaviviruses” were ambiguous, as these words might have referred to all members of the family (viruses of the genera *Flavivirus*, *Hepacivirus*, *Pegivirus*, and *Pestivirus*) or only to those of the genus *Flavivirus*.

To preclude this potential confusion, a taxonomic proposal (TaxoProp 2022.007S.A.Flaviviridae_1genren_spre-named) was submitted to the ICTV in 2022. It proposed that the genus *Flavivirus* be renamed *Orthoflavivirus*, which roughly translates to “true flaviviruses” or “flaviviruses *sensu stricto*”. This proposal was approved by the ICTV Executive Committee in late 2022 and ratified by the ICTV in April 2023 [2, 9]. Consequently, the terms “flaviviral”, “flavivirus”, and “flaviviruses” should be used to refer to the collective members of the family *Flaviviridae*, whereas the terms “orthoflaviviral”, “orthoflavivirus”, and

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“orthoflaviviruses” should be used for viruses of the genus *Orthoflavivirus* (all orthoflaviviruses are flaviviruses, but not all flaviviruses are orthoflaviviruses).

Change to species names in the family *Flaviviridae*

In March 2021, the ICTV ratified TaxoProp 2018.001G.R.binomial_species, which requires all species names to follow a new codified rule:

"A species name shall consist of only two distinct word components separated by a space. The first word component shall begin with a capital letter and be identical in spelling to the name of the genus to which the species belongs. The second word component shall not contain any suffixes specific for taxa of higher ranks. The entire species name (both word components) shall be italicized" [3, 7].

The purpose of this rule is to differentiate more clearly the name of a virus from the name of the species (taxon) to which it is assigned by using the standardized genus + species epithet format found elsewhere in biological taxonomy nomenclature [8]. For orthoflaviviruses, this change was particularly relevant because most species names were the same as the virus names, apart from the orthography; e.g., yellow fever virus was a member of the species *Yellow fever virus*, a situation that created confusion.

The new binomial rule required all names of species previously included in the genus *Flavivirus* to adhere to

the format "*Orthoflavivirus xxxxxx*", in which "xxxxxx" represents a single word. At the same time, the opportunity was taken to abandon the single-letter species epithets used for names of species included in the genera *Hepacivirus*, *Pegivirus*, and *Pestivirus* and instead establish a consistent naming format within the family *Flaviviridae*. New species names were proposed according to guidance outlined by Postler et al. [4] in the same proposal that addressed the genus name issue (TaxoProp 2022.007S.A.Flaviviridae_1genren_sprenamed). Tables 1, 2, 3 and 4 list the current taxonomy of the family *Flaviviridae*, including the prior species names as a reference; Table 5 provides guidance for applying the updated nomenclature in manuscripts.

As with species-renaming proposals elsewhere in virus taxonomy, it should be stressed that these changes to the names of virus species have no influence on the names of the viruses classified within them. Thus, for instance, the virus name "Zika virus" and its abbreviation "ZIKV" remain unchanged even though the species, *Zika virus*, was renamed *Orthoflavivirus zikaense*. Similarly, hepatitis C virus (HCV) remains the same, whereas the species was renamed *Hepacivirus hominis*.

Conclusion

We hope this description of the modifications and replacements of genus and species names is of value by both explaining the reasons for the nomenclature changes and providing a useful reference list for those working in

Table 1 Changes to species names in the genus *Hepacivirus*

Previous species name	New species name [¶]	Virus name (abbreviation) ^{&}
<i>Hepacivirus A</i>	<i>Hepacivirus equi</i>	non-primate hepacivirus (NPHV)
<i>Hepacivirus B</i>	<i>Hepacivirus platyrrhini</i>	GB virus B (GBV-B)
<i>Hepacivirus C</i>	<i>Hepacivirus hominis</i>	hepatitis C virus (HCV)
<i>Hepacivirus D</i>	<i>Hepacivirus colobi</i>	guereza hepacivirus (GHV)
<i>Hepacivirus E</i>	<i>Hepacivirus peromysci</i>	rodent hepacivirus (RHV-E)
<i>Hepacivirus F</i>	<i>Hepacivirus myodae</i>	rodent hepacivirus (RHV-F)
<i>Hepacivirus G</i>	<i>Hepacivirus rattii</i>	Norway rat hepacivirus 1 (NRHV1)
<i>Hepacivirus H</i>	<i>Hepacivirus norvegici</i>	Norway rat hepacivirus 2 (NRHV2)
<i>Hepacivirus I</i>	<i>Hepacivirus rhabdomysis</i>	rodent hepacivirus (RHV-I)
<i>Hepacivirus J</i>	<i>Hepacivirus glareoli</i>	rodent hepacivirus (RHV-J)
<i>Hepacivirus K</i>	<i>Hepacivirus macronycteridis</i>	bat hepacivirus (BHV-K)
<i>Hepacivirus L</i>	<i>Hepacivirus vittatae</i>	bat hepacivirus (BHV-L)
<i>Hepacivirus M</i>	<i>Hepacivirus otomopis</i>	bat hepacivirus (BHV-M)
<i>Hepacivirus N</i>	<i>Hepacivirus bovis</i>	bovine hepacivirus (BoHV)

[¶]Taxon names are always italicized and always begin with a capital letter.

[&]Virus names are not italicized and are not capitalized, except if the name or a name component is a proper noun [8].

Table 2 Changes to species names in the genus *Orthoflavivirus*

Previous species name	New species name [¶]	Virus name (abbreviation) [§]
<i>Apoi virus</i>	<i>Orthoflavivirus apoiense</i>	Apoi virus (APOIV)
<i>Aroa virus</i>	<i>Orthoflavivirus aroaense</i>	Aroa virus (AROAV) Bussuquara virus (BSQV) Iguape virus (IGUV) Naranjal virus (NJLV)
<i>Bagaza virus</i>	<i>Orthoflavivirus bagazaense</i>	Bagaza virus (BAGV)
<i>Banzi virus</i>	<i>Orthoflavivirus banziense</i>	Banzi virus (BANV)
<i>Bouboui virus</i>	<i>Orthoflavivirus boubouiense</i>	Bouboui virus (BOUV)
<i>Bukalasa bat virus</i>	<i>Orthoflavivirus bukalasaense</i>	Bukalasa bat virus (BBV)
<i>Cacipacore virus</i>	<i>Orthoflavivirus cacipacoreense</i>	Cacipacoré virus (CPCV)
<i>Carey Island virus</i>	<i>Orthoflavivirus careyense</i>	Carey Island virus (CIV)
<i>Cowbone Ridge virus</i>	<i>Orthoflavivirus cowboneense</i>	Cowbone Ridge virus (CRV)
<i>Dakar bat virus</i>	<i>Orthoflavivirus dakarensis</i>	Dakar bat virus (DBV)
<i>Dengue virus</i>	<i>Orthoflavivirus denguei</i>	dengue virus type 1 (DENV-1) dengue virus type 2 (DENV-2) dengue virus type 3 (DENV-3) dengue virus type 4 (DENV-4)
<i>Edge Hill virus</i>	<i>Orthoflavivirus edgehillense</i>	Edge Hill virus (EHV)
<i>Entebbe bat virus</i>	<i>Orthoflavivirus entebbeense</i>	Entebbe bat virus (ENTV) Sokuluk virus (SOKV)
<i>Gadgets Gully virus</i>	<i>Orthoflavivirus gadgetsense</i>	Gadgets Gully virus (GGYV)
<i>Ilheus virus</i>	<i>Orthoflavivirus ilheusense</i>	Ilhéus virus (ILHV) Rocio virus (ROCV)
<i>Israel turkey meningoencephalomyelitis virus</i>	<i>Orthoflavivirus israelense</i>	Israel turkey meningoencephalomyelitis virus (ITV)
<i>Japanese encephalitis virus</i>	<i>Orthoflavivirus japonicum</i>	Japanese encephalitis virus (JEV)
<i>Jugra virus</i>	<i>Orthoflavivirus jugraense</i>	Jugra virus (JUGV)
<i>Jutiapa virus</i>	<i>Orthoflavivirus jutiapaense</i>	Jutiapa virus (JUTV)
<i>Kadam virus</i>	<i>Orthoflavivirus kadamense</i>	Kadam virus (KADV)
<i>Kédougou virus</i>	<i>Orthoflavivirus kedougouense</i>	Kédougou virus (KEDV)
<i>Kokobera virus</i>	<i>Orthoflavivirus kokoberaorum</i>	Kokobera virus (KOKV) Stratford virus (STRV)
<i>Koutango virus</i>	<i>Orthoflavivirus koutangoense</i>	Koutango virus (KOUV)
<i>Kyasanur Forest disease virus</i>	<i>Orthoflavivirus kyasanurensis</i>	Alkhumra hemorrhagic fever virus (AHFV) Kyasanur Forest disease virus (KFDV)
<i>Langat virus</i>	<i>Orthoflavivirus langatense</i>	Langat virus (LGTV)
<i>Louping ill virus</i>	<i>Orthoflavivirus loupingi</i>	Greek goat encephalitis virus (GGEV) louping ill virus (LIV) Turkish sheep encephalitis virus (TSEV)
<i>Meaban virus</i>	<i>Orthoflavivirus meabanense</i>	Meaban virus (MEAV)
<i>Modoc virus</i>	<i>Orthoflavivirus modocense</i>	Modoc virus (MODV)
<i>Montana myotis leukoencephalitis virus</i>	<i>Orthoflavivirus montanaense</i>	Montana myotis leukoencephalitis virus (MMLV)
<i>Murray Valley encephalitis virus</i>	<i>Orthoflavivirus murrayense</i>	Alfuy virus (ALFV) Murray Valley encephalitis virus (MVEV)
<i>Ntaya virus</i>	<i>Orthoflavivirus ntayaense</i>	Ntaya virus (NTAV)
<i>Omsk hemorrhagic fever virus</i>	<i>Orthoflavivirus omskense</i>	Omsk hemorrhagic fever virus (OHFV)
<i>Phnom Penh bat virus</i>	<i>Orthoflavivirus phnompenhense</i>	Batu Cave virus (BCV) Phnom Penh bat virus (PPBV)
<i>Powassan virus</i>	<i>Orthoflavivirus powassanense</i>	deer tick virus (DTV) Powassan virus (POWV)
<i>Rio Bravo virus</i>	<i>Orthoflavivirus bravoense</i>	Rio Bravo virus (RBV)

Table 2 (continued)

Previous species name	New species name [¶]	Virus name (abbreviation) ^{&}
<i>Royal Farm virus</i>	<i>Orthoflavivirus royalense</i>	Royal Farm virus (RFV)
<i>Saboya virus</i>	<i>Orthoflavivirus saboyaense</i>	Potiskum virus (POTV) Saboya virus (SABV)
<i>Saint Louis encephalitis virus</i>	<i>Orthoflavivirus louisense</i>	St. Louis encephalitis virus (SLEV)
<i>San Perlita virus</i>	<i>Orthoflavivirus perlitaense</i>	San Perlita virus (SPV)
<i>Sal Vieja virus</i>	<i>Orthoflavivirus viejaense</i>	Sal Vieja virus (SVV)
<i>Saumarez Reef virus</i>	<i>Orthoflavivirus saumarezense</i>	Saumarez Reef virus (SREV)
<i>Sepik virus</i>	<i>Orthoflavivirus sepikense</i>	Sepik virus (SEPV)
<i>Tembusu virus</i>	<i>Orthoflavivirus tembusu</i>	Tembusu virus (TMUV)
<i>Tick-borne encephalitis virus</i>	<i>Orthoflavivirus encephalitis</i>	tick-borne encephalitis virus (TBEV)
<i>Tyuleniy virus</i>	<i>Orthoflavivirus tyuleniyense</i>	Tyuleniy virus (TYUV)
<i>Uganda S virus</i>	<i>Orthoflavivirus ugandaense</i>	Uganda S virus (UGSV)
<i>Usutu virus</i>	<i>Orthoflavivirus usutuense</i>	Usutu virus (USUV)
<i>Wesselsbron virus</i>	<i>Orthoflavivirus wesselsbronense</i>	Wesselsbron virus (WESSV)
<i>West Nile virus</i>	<i>Orthoflavivirus nilense</i>	Kunjin virus (KUNV) West Nile virus (WNV)
<i>Yaounde virus</i>	<i>Orthoflavivirus yaoundeense</i>	Yaoundé virus (YAOV)
<i>Yellow fever virus</i>	<i>Orthoflavivirus flavi</i>	yellow fever virus (YFV)
<i>Yokose virus</i>	<i>Orthoflavivirus yokoseense</i>	Yokose virus (YOKV)
<i>Zika virus</i>	<i>Orthoflavivirus zikaense</i>	Zika virus (ZIKV)

[¶]Taxon names are always italicized and always begin with a capital letter.

[&]Virus names are not italicized and are not capitalized, except if the name or a name component is a proper noun [8].

Table 3 Changes to species names in the genus *Pegivirus*

Previous species name	New species name [¶]	Virus name (abbreviation) ^{&}
<i>Pegivirus A</i>	<i>Pegivirus platyrrhini</i>	GB virus-A (GBV-A)
<i>Pegivirus B</i>	<i>Pegivirus pteropi</i>	GB virus-D (GBV-D)
<i>Pegivirus C</i>	<i>Pegivirus hominis</i>	human pegivirus (HPgV)
<i>Pegivirus D</i>	<i>Pegivirus equi</i>	Theiler's disease-associated virus (TDAV)
<i>Pegivirus E</i>	<i>Pegivirus caballi</i>	equine pegivirus (EPgV)
<i>Pegivirus F</i>	<i>Pegivirus carolliae</i>	bat pegivirus F (BPgV-F)
<i>Pegivirus G</i>	<i>Pegivirus scotophili</i>	bat pegivirus G (BPgV-G)
<i>Pegivirus H</i>	<i>Pegivirus columbiaense</i>	human hepegivirus (HHPgV)
<i>Pegivirus I</i>	<i>Pegivirus sturnirae</i>	bat pegivirus I (BPgV-I)
<i>Pegivirus J</i>	<i>Pegivirus neotomae</i>	rodent pegivirus (RPgV)
<i>Pegivirus K</i>	<i>Pegivirus suis</i>	porcine pegivirus (PPgV)

[¶]Taxon names are always italicized and always begin with a capital letter.

[&]Virus names are not italicized and are not capitalized, except if the name or a name component is a proper noun [8].

Table 4 Changes to species names in the genus *Pestivirus*

Previous species name (if applicable)	New species name [‡]	Virus name (abbreviation) ^{&}
<i>Pestivirus A</i>	<i>Pestivirus bovis</i>	bovine viral diarrhoea virus 1 (BVDV1)
<i>Pestivirus B</i>	<i>Pestivirus tauri</i>	bovine viral diarrhoea virus 2 (BVDV2)
<i>Pestivirus C</i>	<i>Pestivirus suis</i>	classical swine fever virus (CSFV)
<i>Pestivirus D</i>	<i>Pestivirus ovis</i>	border disease virus (BDV)
<i>Pestivirus E</i>	<i>Pestivirus antilocaprae</i>	pronghorn antelope pestivirus (PAPeV)
<i>Pestivirus F</i>	<i>Pestivirus australiaense</i>	Bungowannah virus (BuPV)
<i>Pestivirus G</i>	<i>Pestivirus giraffae</i>	giraffe pestivirus (GPeV)
<i>Pestivirus H</i>	<i>Pestivirus brazilense</i>	HoBi-like pestivirus (HoBiPeV)
<i>Pestivirus I</i>	<i>Pestivirus aydinense</i>	Aydin-like pestivirus (AydinPeV)
<i>Pestivirus J</i>	<i>Pestivirus rattii</i>	rat pestivirus (RPeV)
<i>Pestivirus K</i>	<i>Pestivirus scrofae</i>	atypical porcine pestivirus (APPeV)
/	<i>Pestivirus L</i> (proposed to be renamed as “ <i>Pestivirus austriacense</i> ”)	Linda virus (LindaV)
/	<i>Pestivirus M</i> (proposed to be renamed as “ <i>Pestivirus phocoenae</i> ”)	Phocoena pestivirus (PhoPeV)
/	<i>Pestivirus N</i> (proposed to be renamed as “ <i>Pestivirus tunisiaense</i> ”)	Tunisian sheep-like pestivirus (TSV)
/	<i>Pestivirus O</i> (proposed to be renamed as “ <i>Pestivirus italiaense</i> ”)	ovine/IT pestivirus (ovIT PeV)
/	<i>Pestivirus P</i> (proposed to be renamed as “ <i>Pestivirus pholidotae</i> ”)	pangolin pestivirus (DYPV)
/	<i>Pestivirus Q</i> (proposed to be renamed as “ <i>Pestivirus niviventris</i> ”)	rodent pestivirus (RtNn-PeV)
/	<i>Pestivirus R</i> (proposed to be renamed as “ <i>Pestivirus apodemi</i> ”)	rodent pestivirus (RtAp-PeV)
/	<i>Pestivirus S</i> (proposed to be renamed as “ <i>Pestivirus scotophil</i> ”)	bat pestivirus (BtSk-PeV)

[‡]Taxon names are always italicized and always begin with a capital letter.

[&]Virus names are not italicized and are not capitalized, except if the name or a name component is a proper noun [8].

Table 5 Identification of potential nomenclature problems in manuscripts pertaining to the family *Flaviviridae* and its viruses

Manuscript check	Action
Search for the terms listed in Tables 1, 2, 3 and 4, column 1	These terms are outdated species names. Replace with current species names (Tables 1, 2, 3 and 4, column 2).
Search for the current species names listed in Tables 1, 2, 3 and 4, column 2	Typically, species names will be listed only once in the introductory or methods section followed by a link to their member viruses. Check to see whether species names used elsewhere in the manuscript can be replaced with the appropriate virus names and/or their abbreviations as listed in Tables 1, 2, 3 and 4, column 3.
Search for the term “ <i>Flavivirus</i> ”	This genus name has been abolished. Replace with “ <i>Orthoflavivirus</i> ”. Note that the genus name “ <i>Orthoflavivirus</i> ” is capitalized and italicized, but the name of its collective members, i.e., “orthoflaviviruses”, is written in lower case and is not italicized (this applies to all genera).
Search for the terms “flavivirus”, “flaviviruses”, and “flaviviral”	If referring to the collective members of the genus <i>Orthoflavivirus</i> , replace with “orthoflavivirus”, “orthoflaviviruses”, and “orthoflaviviral”, respectively. If referring collectively to members of the family <i>Flaviviridae</i> , then the terms are correctly applied.
Search for the term “ <i>Flaviviridae</i> ”	Check if it would be more appropriate to replace the family name “ <i>Flaviviridae</i> ” with “flavivirus”, “flavivirid”, or “members of the family <i>Flaviviridae</i> ”.

the field. The ICTV Online Report chapter on the family *Flaviviridae* has also been updated with the new genus and species names [6].

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Declarations

Conflict of interest The authors declare no conflicts of interest.

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