

Taxonomy of the order *Mononegavirales*: update 2016

Claudio L. Afonso¹ · Gaya K. Amarasinghe²  · Krisztián Bányai³ · Yīmíng Bào⁴ · Christopher F. Basler⁵  · Sina Bavari⁶ · Nicolás Bejerman^{7,8}  · Kim R. Blasdel⁹ · François-Xavier Briand¹⁰ · Thomas Briese¹¹ · Alexander Bukreyev¹² · Charles H. Calisher¹³ · Kartik Chandran¹⁴  · Jiāsēn Chéng¹⁵ · Anna N. Clawson¹⁶ · Peter L. Collins¹⁷ · Ralf G. Dietzgen¹⁸  · Olga Dolnik¹⁹  · Leslie L. Domier²⁰ · Ralf Dürwald²¹ · John M. Dye⁶ · Andrew J. Easton²²  · Hideki Ebihara²³ · Szilvia L. Farkas³  · Juliana Freitas-Astúa²⁴  · Pierre Formenty²⁵  · Ron A. M. Fouchier²⁶ · Yànpíng Fù¹⁵ · Elodie Ghedin²⁷  · Michael M. Goodin²⁸ · Roger Hewson²⁹  · Masayuki Horie³⁰ · Timothy H. Hyndman³¹ · Dàohóng Jiāng¹⁵ · Elliot W. Kitajima³²  · Gary P. Kobinger³³ · Hideki Kondo³⁴ · Gael Kurath³⁵  · Robert A. Lamb^{36,37} · Sergio Lenardon⁷ · Eric M. Leroy³⁸ · Ci-Xiu Li⁴⁰ · Xian-Dan Lin⁴¹ · Lǐjiāng Liú¹⁵ · Ben Longdon⁴²  · Szilvia Marton³ · Andrea Maisner¹⁹ · Elke Mühlberger⁴³ · Sergey V. Netesov⁴⁴ · Norbert Nowotny^{45,46} · Jean L. Patterson⁴⁷ · Susan L. Payne⁴⁸ · Janusz T. Paweska⁴⁹ · Rick E. Randall⁵⁰ · Bertus K. Rima⁵¹ · Paul Rota⁵² · Dennis Rubbenstroth⁵³ · Martin Schwemmler⁵³ · Mang Shi³⁹ · Sophie J. Smither⁵⁴ · Mark D. Stenglein⁵⁵  · David M. Stone⁵⁶ · Ayato Takada⁵⁷ · Calogero Terregino⁵⁸  · Robert B. Tesh¹² · Jun-Hua Tian⁵⁹ · Keizo Tomonaga⁶⁰ · Noël Tordo^{61,62} · Jonathan S. Towner⁶³ · Nikos Vasilakis^{64,65}  · Martin Verbeek⁶⁶  · Viktor E. Volchkov⁶⁷ · Victoria Wahl-Jensen⁶⁸  · John A. Walsh²² · Peter J. Walker⁹ · David Wang⁶⁹ · Lin-Fa Wang^{70,71} · Thierry Wetzel⁷² · Anna E. Whitfield⁷³  · Jiǎtāo Xiè¹⁵ · Kwok-Yung Yuen⁷⁴ · Yong-Zhen Zhang³⁹ · Jens H. Kuhn¹⁶ 

Received: 19 April 2016 / Accepted: 27 April 2016 / Published online: 23 May 2016
© Springer-Verlag Wien (Outside the USA) 2016

✉ Jens H. Kuhn
kuhnjens@mail.nih.gov

- ¹ Southeast Poultry Research Laboratory, Agricultural Research Service, US Department of Agriculture, Athens, GA, USA
- ² Department of Pathology and Immunology, Washington University School of Medicine, St. Louis, MO, USA
- ³ Institute for Veterinary Medical Research, Centre for Agricultural Research, Hungarian Academy of Sciences, Budapest, Hungary
- ⁴ Information Engineering Branch, National Center for Biotechnology Information, National Library of Medicine, National Institutes of Health, Bethesda, MD, USA
- ⁵ Center for Microbial Pathogenesis, Institute for Biomedical Sciences, Georgia State University, Atlanta, GA, USA
- ⁶ United States Army Medical Research Institute of Infectious Diseases, Fort Detrick, Frederick, MD, USA
- ⁷ Instituto de Patología Vegetal, Centro de Investigaciones Agropecuarias, Instituto Nacional de Tecnología Agropecuaria, Córdoba, Argentina
- ⁸ Consejo Nacional de Investigaciones Científicas y Técnicas, Buenos Aires, Argentina
- ⁹ CSIRO Health and Biosecurity, Australian Animal Health Laboratory, Geelong, VIC, Australia

- ¹⁰ Avian and Rabbit Virology Immunology and Parasitology Unit, French Agency for Food, Environmental and Occupational Health and Safety, Ploufragan, France
- ¹¹ Center for Infection and Immunity, Mailman School of Public Health, Columbia University, New York, NY, USA
- ¹² Departments of Pathology and Microbiology & Immunology, Galveston National Laboratory, The University of Texas Medical Branch, Galveston, TX, USA
- ¹³ Arthropod-Borne and Infectious Diseases Laboratory, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Fort Collins, CO, USA
- ¹⁴ Department of Microbiology and Immunology, Albert Einstein College of Medicine, Bronx, NY, USA
- ¹⁵ State Key Laboratory of Agricultural Microbiology, The Provincial Key Lab of Plant Pathology of Húběi Province, College of Plant Science and Technology, Huázhōng Agricultural University, Wuhan, China
- ¹⁶ Integrated Research Facility at Fort Detrick (IRF-Frederick), Division of Clinical Research (DCR), National Institute of Allergy and Infectious Diseases (NIAID), National Institutes of Health (NIH), B-8200 Research Plaza, Fort Detrick, Frederick, MD 21702, USA
- ¹⁷ Respiratory Viruses Section, Laboratory of Infectious Diseases, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, MD, USA

Abstract In 2016, the order *Mononegavirales* was emended through the addition of two new families (*Mymonaviridae* and *Sunviridae*), the elevation of the paramyxoviral subfamily *Pneumovirinae* to family status (*Pneumoviridae*), the addition of five free-floating genera (*Anphevirus*, *Arlivirus*, *Chengtivirus*, *Crustavirus*, and *Wastrivirus*), and several other changes at the genus and species levels. This article presents the updated taxonomy of the order *Mononegavirales* as now accepted by the International Committee on Taxonomy of Viruses (ICTV).

Introduction

The viral order *Mononegavirales* was established in 1991 to accommodate related viruses with nonsegmented, linear, single-stranded negative-sense RNA genomes. These

viruses were initially assigned to three mononegaviral families: *Filoviridae*, *Paramyxoviridae*, and *Rhabdoviridae* [20, 21]. In subsequent years, these families continued to grow through the inclusion of numerous novel species and genera, and the order was therefore emended in 1995 [4], 1997 [23], 2000 [24], 2005 [25], and 2011 [8]. The families *Bornaviridae* and *Nyamiviridae* joined the other three mononegaviral families in 1996 [22] and 2014 [1, 11], respectively. In 2015, the Study Groups of the International Committee on Taxonomy of Viruses (ICTV) responsible for the taxonomy of the order and its five families embarked on a joint effort to assign unclassified mononegaviruses to existing or novel taxa and to streamline order nomenclature. Here we present a brief overview of the first round of these efforts, which by now is accepted by the ICTV Executive Committee and, thereby, is official taxonomy.

¹⁸ Queensland Alliance for Agriculture and Food Innovation, The University of Queensland, St. Lucia, QLD, Australia

¹⁹ Institute of Virology, Philipps University Marburg, Marburg, Germany

²⁰ Department of Crop Sciences, University of Illinois, Champaign, IL, USA

²¹ IDT Biologika, Dessau-Rosslau, Germany

²² School of Life Sciences, University of Warwick, Coventry, UK

²³ Rocky Mountain Laboratories Integrated Research Facility, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Hamilton, MT, USA

²⁴ Embrapa Cassava and Fruits, Cruz das Almas, Bahia, Brazil

²⁵ World Health Organization, Geneva, Switzerland

²⁶ Department of Viroscience, Postgraduate School Molecular Medicine, Erasmus University Medical Center, Rotterdam, The Netherlands

²⁷ Department of Biology, Center for Genomics and Systems Biology, New York University, New York, NY, USA

²⁸ Plant Pathology, University of Kentucky, Lexington, KY, USA

²⁹ Public Health England, Porton Down, Wiltshire, Salisbury, UK

³⁰ Joint Faculty of Veterinary Medicine, Transboundary Animal Diseases Research Center, Kagoshima University, Kagoshima, Japan

³¹ School of Veterinary and Life Sciences, Murdoch University, Murdoch, WA, Australia

³² Núcleo de Apoio à Pesquisa em Microscopia Eletrônica Aplicada a Agricultura, Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo, Piracicaba, São Paulo, Brazil

³³ Special Pathogens Program, National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, MB, Canada

³⁴ Institute of Plant Science and Resources, Okayama University, Kurashiki, Japan

³⁵ US Geological Survey Western Fisheries Research Center, Seattle, WA, USA

³⁶ Department of Molecular Biosciences, Northwestern University, Evanston, IL, USA

³⁷ Howard Hughes Medical Institute, Northwestern University, Evanston, IL, USA

³⁸ Centre International de Recherches Médicales de Franceville, Institut de Recherche pour le Développement, Franceville, Gabon

Taxonomic changes at the order level

In recent years, several mononegaviruses have been described that are only distantly related to the members of the families *Bornaviridae*, *Filoviridae*, *Nyamiviridae*, *Paramyxoviridae*, and *Rhabdoviridae*. These viruses include Sclerotinia sclerotiorum negative-stranded RNA virus 1 (SsNSRV-1) found in an ascomycete in China [16]; Sunshine Coast virus (SunCV; previously called Sunshine virus) isolated from Australian carpet pythons [10]; and Líshí spider virus 2 (LsSV-2), Sānxiá water strider virus 4 (SxWSV-4), Tǎchéng tick virus 6 (TcTV-6), Wēnzhōu crab virus 1 (WzCV-1), and Xīnchéng mosquito virus (XcMV) detected in Chinese arthropods [15]. To accommodate these viruses in the order and to appropriately reflect their phylogenetic relationships to other mononegaviral taxa, two new families and four free-floating genera were established:

Mymonaviridae (accommodating SsNSRV-1), *Sunviridae* (SunCV), *Anphevirus* (XcMV), *Arivirus* (LsSV-2), *Chengtivirus* (TcTV-6), *Crustavirus* (WzCV-1), and *Wastrivirus* (SxWSV-4). In addition, the paramyxoviral subfamily *Pneumovirinae* was elevated to family status (*Pneumoviridae*) because the members of this taxon are as closely related to filoviruses as to the members of the paramyxoviral subfamily *Paramyxovirinae* (now dissolved) (Table 1).

Taxonomic changes at the family level

The monogeneric family *Bornaviridae* was reorganized in 2015 by establishing five distinct species in the genus *Bornavirus* [2, 12] following a non-Latinized binomial species name format [29]. These efforts were continued in 2016 by expanding the genus by an additional two species

- ³⁹ State Key Laboratory for Infectious Disease Prevention and Control, National Institute for Communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China
- ⁴⁰ Collaborative Innovation Center for Diagnosis and Treatment of Infectious Diseases, Hangzhou, China
- ⁴¹ Wēnzhōu Center for Disease Control and Prevention, Wenzhou, China
- ⁴² Department of Genetics, University of Cambridge, Cambridge, UK
- ⁴³ Department of Microbiology and National Emerging Infectious Diseases Laboratory, Boston University School of Medicine, Boston, MA, USA
- ⁴⁴ Novosibirsk State University, Novosibirsk, Novosibirsk Oblast, Russia
- ⁴⁵ Institute of Virology, University of Veterinary Medicine, Vienna, Austria
- ⁴⁶ Department of Basic Medical Sciences, College of Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai, United Arab Emirates
- ⁴⁷ Department of Virology and Immunology, Texas Biomedical Research Institute, San Antonio, TX, USA
- ⁴⁸ Department of Veterinary Pathobiology, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University, College Station, TX, USA

- ⁴⁹ Center for Emerging and Zoonotic Diseases, National Institute for Communicable Diseases of the National Health Laboratory Service, Sandringham-Johannesburg, Gauteng, South Africa
- ⁵⁰ Biomedical Sciences Research Complex, University of St. Andrews, St. Andrews, Scotland, UK
- ⁵¹ Centre for Experimental Medicine, School of Medicine, Dentistry and Biomedical Sciences, The Queen's University of Belfast, Belfast, Northern Ireland, UK
- ⁵² National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA
- ⁵³ Institute for Virology, Faculty of Medicine, Medical Center—University of Freiburg, University of Freiburg, Freiburg, Germany
- ⁵⁴ CBR Division, Dstl, Porton Down, Salisbury, Wiltshire, UK
- ⁵⁵ Department of Microbiology, Immunology, and Pathology, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Fort Collins, CO, USA
- ⁵⁶ Centre for Environment, Fisheries and Aquaculture Science Weymouth, Dorset, UK
- ⁵⁷ Division of Global Epidemiology, Hokkaido University Research Center for Zoonosis Control, Sapporo, Japan

(*Elapid 1 bornavirus* for Loveridge's garter snake virus 1 [27] and *Psittaciform 2 bornavirus* for parrot bornavirus 5 [9, 18]) (Table 1).

The monogeneric family *Nyamiviridae* was expanded to include a second genus (*Socyvirus*) for the until-then free-floating nyamivirus species *Soybean cyst nematode virus*. This species name was changed to *Soybean cyst nematode socyvirus* to adhere to the non-Latinized binomial species name format [29] (Table 1).

The family *Paramyxoviridae* was emended by expanding the genus *Avulavirus* by three species (*Avian paramyxovirus 10-12* for avian paramyxoviruses 10-12, respectively [5, 19, 28]), the genus *Henipavirus* by three species (*Cedar henipavirus* for Cedar virus [17], *Ghanaian bat henipavirus* for Kumasi virus [GH-M74a] [7], and *Mojiang henipavirus* for Mōjiāng virus [31]), the genus *Morbillivirus* by one species (*Feline morbillivirus* for

feline morbillivirus [30]) and the genus *Respirovirus* by one species (*Porcine parainfluenza virus 1* for porcine parainfluenza virus 1 [14]). The species *Simian Virus 10* was dissolved on the evidence that simian virus 10 is an isolate of human parainfluenzavirus 3 rather than a distinct virus [13]. The genus *Pneumovirus*, now included in the new family *Pneumoviridae*, was renamed *Orthopneumovirus* to avoid confusion between family and genus members (Table 1).

The family *Rhabdoviridae* was expanded by two genera: *Dichorhavirus* (new; [6]) and *Varicosavirus* (previously free-floating outside of the order) to accommodate bisegmented plant viruses (coffee ringspot virus and orchid fleck virus; lettuce big-vein associated virus). The species *Alfalfa dwarf cytorhabdovirus* (for alfalfa dwarf virus [3]) was added to the genus *Cytorhabdovirus*. Finally, the non-

⁵⁸ Istituto Zooprofilattico Sperimentale delle Venezie, Department of Comparative Biomedical Sciences, National/OIE Reference Laboratory for Newcastle Disease and Avian Influenza, FAO Reference Centre for Animal Influenza and Newcastle Disease, OIE Collaborating Centre for Diseases at the Human-Animal Interface, Legnaro, Padova, Italy

⁵⁹ Wūhàn Center for Disease Control and Prevention, Wuhan, China

⁶⁰ Institute for Virus Research, Kyoto University, Kyoto, Japan

⁶¹ Institut Pasteur, Unité des Stratégies Antivirales, Paris, France

⁶² Institut Pasteur de Guinée, Conakry, Guinea

⁶³ Viral Special Pathogens Branch, Division of High-Consequence Pathogens Pathology, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA

⁶⁴ Center for Biodefense and Emerging Infectious Diseases, Department of Pathology, The University of Texas Medical Branch, Galveston, TX, USA

⁶⁵ Center for Tropical Diseases, Institute for Human Infections and Immunity, The University of Texas Medical Branch, Galveston, TX, USA

⁶⁶ Wageningen University and Research, Wageningen, The Netherlands

⁶⁷ Molecular Basis of Viral Pathogenicity, CIRI, INSERM U1111, CNRS UMR5308, Université de Lyon, Université Claude Bernard Lyon 1, Ecole Normale Supérieure de Lyon, Lyon, France

⁶⁸ National Biodefense Analysis and Countermeasures Center, Fort Detrick, Frederick, MD, USA

⁶⁹ Departments of Molecular Microbiology and Pathology and Immunology, Washington University School of Medicine, St. Louis, MO, USA

⁷⁰ Department of Agriculture and Fisheries, Biosecurity Queensland, Brisbane, QLD, Australia

⁷¹ Program in Emerging Infectious Diseases, Duke-NUS Graduate Medical School, Singapore, Singapore

⁷² DLR Rheinpfalz, Institute of Plant Protection, Neustadt an der Weinstrasse, Germany

⁷³ Plant Pathology, Kansas State University, Manhattan, KS, USA

⁷⁴ State Key Laboratory of Emerging Infectious Diseases, Department of Microbiology, University of Hong Kong, Hong Kong Special Administrative Region, Hong Kong, China

Table 1 Taxonomy of the order *Mononegavirales* as of 2016

Genus	Species	Virus (abbreviation)	
Family <i>Bornaviridae</i>			
<i>Bornavirus</i>	<i>Elapid 1 bornavirus</i>	Loveridge's garter snake virus 1 (LGSV-1)	
	<i>Mammalian 1 bornavirus*</i>	Borna disease virus 1 (BoDV-1)	
		Borna disease virus 2 (BoDV-2)	
	<i>Passeriform 1 bornavirus</i>		canary bornavirus 1 (CnBV-1)
			canary bornavirus 2 (CnBV-2)
			canary bornavirus 3 (CnBV-3)
	<i>Passeriform 2 bornavirus</i>	estrildid finch bornavirus 1 (EsBV-1)	
	<i>Psittaciform 1 bornavirus</i>		parrot bornavirus 1 (PaBV-1)
			parrot bornavirus 2 (PaBV-2)
			parrot bornavirus 3 (PaBV-3)
			parrot bornavirus 4 (PaBV-4)
			parrot bornavirus 7 (PaBV-7)
	<i>Psittaciform 2 bornavirus</i>		parrot bornavirus 5 (PaBV-5)
<i>Waterbird 1 bornavirus</i>		aquatic bird bornavirus 1 (ABBV-1)	
	aquatic bird bornavirus 2 (ABBV-2)		
Family <i>Filoviridae</i>			
<i>Cuevavirus</i>	<i>Lloviu cuevavirus*</i>	Lloviu virus (LLOV)	
<i>Ebolavirus</i>	<i>Bundibugyo ebolavirus</i>	Bundibugyo virus (BDBV)	
	<i>Reston ebolavirus</i>	Reston virus (RESTV)	
	<i>Sudan ebolavirus</i>	Sudan virus (SUDV)	
	<i>Tai Forest ebolavirus</i>	Tai Forest virus (TAFV)	
	<i>Zaire ebolavirus*</i>	Ebola virus (EBOV)	
<i>Marburgvirus</i>	<i>Marburg marburgvirus*</i>	Marburg virus (MARV)	
		Ravn virus (RAVV)	
Family <i>Myonaviridae</i>			
<i>Sclerotimonavirus</i>	<i>Sclerotinia sclerotimonavirus*</i>	Sclerotinia sclerotiorum negative-stranded RNA virus 1 (SsNSRV-1)	
Family <i>Nyamiviridae</i>			
<i>Nyavirus</i>	<i>Midway nyavirus</i>	Midway virus (MIDWV)	
	<i>Nyamanini nyavirus*</i>	Nyamanini virus (NYMV)	
	<i>Sierra Nevada nyavirus</i>	Sierra Nevada virus (SNVV)	
<i>Socyvirus</i>	<i>Soybean cyst nematode socyvirus*</i>	soybean cyst nematode virus 1 (SbCNV-1)	
Family <i>Paramyxoviridae</i>			
<i>Aquaparamyxovirus</i>	<i>Atlantic salmon paramyxovirus*</i>	Atlantic salmon paramyxovirus (AsaPV)	
<i>Avulavirus</i>	<i>Avian paramyxovirus 2</i>	avian paramyxovirus 2 (APMV-2)	
	<i>Avian paramyxovirus 3</i>	avian paramyxovirus 3 (APMV-3)	
	<i>Avian paramyxovirus 4</i>	avian paramyxovirus 4 (APMV-4)	
	<i>Avian paramyxovirus 5</i>	avian paramyxovirus 5 (APMV-5)	
	<i>Avian paramyxovirus 6</i>	avian paramyxovirus 6 (APMV-6)	
	<i>Avian paramyxovirus 7</i>	avian paramyxovirus 7 (APMV-7)	
	<i>Avian paramyxovirus 8</i>	avian paramyxovirus 8 (APMV-8)	
	<i>Avian paramyxovirus 9</i>	avian paramyxovirus 9 (APMV-9)	
	<i>Avian paramyxovirus 10</i>	avian paramyxovirus 10 (APMV-10)	
	<i>Avian paramyxovirus 11</i>	avian paramyxovirus 11 (APMV-11)	
	<i>Avian paramyxovirus 12</i>	avian paramyxovirus 12 (APMV-12)	
	<i>Newcastle disease virus*</i>	avian paramyxovirus 1 (APMV-1) ^a	

Table 1 continued

Genus	Species	Virus (abbreviation)	
<i>Ferlavirus</i>	<i>Fer-de-Lance paramyxovirus</i> *	Fer-de-Lance virus (FDLV) ^b	
<i>Henipavirus</i>	<i>Cedar henipavirus</i>	Cedar virus (CedV)	
	<i>Ghanaian bat henipavirus</i>	Kumasi virus (KV) ^c	
	<i>Hendra virus</i> *	Hendra virus (HeV)	
	<i>Mojiang henipavirus</i>	Mòjiāng virus (MojV)	
	<i>Nipah virus</i>	Nipah virus (NiV)	
<i>Morbillivirus</i>	<i>Canine distemper virus</i>	canine distemper virus (CDV)	
	<i>Cetacean morbillivirus</i>	cetacean morbillivirus (CeMV)	
	<i>Feline morbillivirus</i>	feline morbillivirus (FeMV) ^d	
	<i>Measles virus</i> *	measles virus (MeV)	
	<i>Peste-des-petits-ruminants virus</i>	peste-des-petits-ruminants virus (PPRV)	
	<i>Phocine distemper virus</i>	phocine distemper virus (PDV)	
<i>Respirovirus</i>	<i>Rinderpest virus</i>	rinderpest virus (RPV)	
	<i>Bovine parainfluenza virus 3</i>	bovine parainfluenza virus 3 (BPIV-3)	
	<i>Human parainfluenza virus 1</i>	human parainfluenza virus 1 (HPIV-1)	
	<i>Human parainfluenza virus 3</i>	human parainfluenza virus 3 (HPIV-3) ^e	
	<i>Porcine parainfluenza virus 1</i>	porcine parainfluenza virus 1 (PPIV-1)	
<i>Rubulavirus</i>	<i>Sendai virus</i> *	Sendai virus (SeV) ^f	
	<i>Human parainfluenza virus 2</i>	human parainfluenza virus 2 (HPIV-2)	
	<i>Human parainfluenza virus 4</i>	human parainfluenza virus 4a (HPIV-4a) human parainfluenza virus 4b (HPIV-4b)	
	<i>Mapuera virus</i>	Mapuera virus (MapV)	
	<i>Mumps virus</i> *	mumps virus (MuV) bat mumps virus (BMV) ^g	
	<i>Parainfluenza virus 5</i>	parainfluenza virus 5 (PIV-5) ^h	
	<i>Porcine rubulavirus</i>	La Piedad Michoacán Mexico virus (LPMV) ⁱ	
	<i>Simian virus 41</i>	simian virus 41 (SV-41)	
	Family <i>Pneumoviridae</i>		
	<i>Metapneumovirus</i>	<i>Avian metapneumovirus</i> *	avian metapneumovirus (AMPV) ^j
<i>Human metapneumovirus</i>		human metapneumovirus (HMPV)	
<i>Orthopneumovirus</i>	<i>Bovine respiratory syncytial virus</i>	bovine respiratory syncytial virus (BRSV)	
	<i>Human respiratory syncytial virus</i> *	human respiratory syncytial virus A2 (HRSV-A2) human respiratory syncytial virus B1 (HRSV-B1) human respiratory syncytial virus S2 (HRSV-S2)	
	<i>Murine pneumonia virus</i>	murine pneumonia virus (MPV)	
Family <i>Rhabdoviridae</i>			
<i>Cytorhabdovirus</i>	<i>Alfalfa dwarf cytorhabdovirus</i>	alfalfa dwarf virus (ADV)	
	<i>Barley yellow striate mosaic cytorhabdovirus</i>	barley yellow striate mosaic virus (BYSMV)	
	<i>Broccoli necrotic yellows cytorhabdovirus</i>	broccoli necrotic yellows virus (BNYV)	
	<i>Festuca leaf streak cytorhabdovirus</i>	festuca leaf streak virus (FLSV)	
	<i>Lettuce necrotic yellows cytorhabdovirus</i> *	lettuce necrotic yellows virus (LNYV)	
	<i>Lettuce yellow mottle cytorhabdovirus</i>	lettuce yellow mottle virus (LYMoV)	
	<i>Northern cereal mosaic cytorhabdovirus</i>	northern cereal mosaic virus (NCMV)	
	<i>Sonchus cytorhabdovirus 1</i>	sonchus virus (SonV)	
	<i>Strawberry crinkle cytorhabdovirus</i>	strawberry crinkle virus (SCV)	
	<i>Wheat American striate mosaic cytorhabdovirus</i>	wheat American striate mosaic virus (WASMV)	

Table 1 continued

Genus	Species	Virus (abbreviation)
<i>Dichorhavirus</i>	<i>Coffee ringspot dichorhavirus</i>	coffee ringspot virus (CoRSV)
	<i>Orchid fleck dichorhavirus</i> *	orchid fleck virus (OFV) ^k
<i>Ephemerovirus</i>	<i>Adelaide River ephemerovirus</i>	Adelaide River virus (ARV)
	<i>Berrimah ephemerovirus</i>	Berrimah virus (BRMV)
	<i>Bovine fever ephemerovirus</i> *	bovine ephemeral fever virus (BEFV) ^l
	<i>Kotonkan ephemerovirus</i>	kotonkan virus (KOTV)
	<i>Obodhiang ephemerovirus</i>	Obodhiang virus (OBOV)
<i>Lyssavirus</i>	<i>Aravan lyssavirus</i>	Aravan virus (ARAV)
	<i>Australian bat lyssavirus</i>	Australian bat lyssavirus (ABLV)
	<i>Bokeloh bat lyssavirus</i>	Bokeloh bat lyssavirus (BBLV)
	<i>Duvenhage lyssavirus</i>	Duvenhage virus (DUVV)
	<i>European bat 1 lyssavirus</i>	European bat lyssavirus 1 (EBLV-1)
	<i>European bat 2 lyssavirus</i>	European bat lyssavirus 2 (EBLV-2)
	<i>Ikoma lyssavirus</i>	Ikoma lyssavirus (IKOV)
	<i>Irkut lyssavirus</i>	Irkut virus (IRKV)
	<i>Khujand lyssavirus</i>	Khujand virus (KHUV)
	<i>Lagos bat lyssavirus</i>	Lagos bat virus (LBV)
	<i>Mokola lyssavirus</i>	Mokola virus (MOKV)
	<i>Rabies lyssavirus</i> *	rabies virus (RABV)
	<i>Shimoni bat lyssavirus</i>	Shimoni bat virus (SHIBV)
	<i>West Caucasian bat lyssavirus</i>	West Caucasian bat virus (WCBV)
<i>Novirhabdovirus</i>	<i>Hirame novirhabdovirus</i>	Hirame rhabdovirus (HIRV)
	<i>Oncorhynchus 1 novirhabdovirus</i> *	infectious hematopoietic necrosis virus (IHNV)
	<i>Oncorhynchus 2 novirhabdovirus</i>	viral hemorrhagic septicemia virus (VHSV) ^m
	<i>Snakehead novirhabdovirus</i>	snakehead rhabdovirus (SHRV)
<i>Nucleorhabdovirus</i>	<i>Datura yellow vein nucleorhabdovirus</i>	datura yellow vein virus (DYVV)
	<i>Eggplant mottled dwarf nucleorhabdovirus</i>	eggplant mottled dwarf virus (EMDV)
	<i>Maize fine streak nucleorhabdovirus</i>	maize fine streak virus (MSFV)
	<i>Maize Iranian mosaic nucleorhabdovirus</i>	maize Iranian mosaic virus (MIMV)
	<i>Maize mosaic nucleorhabdovirus</i>	maize mosaic virus (MMV)
	<i>Potato yellow dwarf nucleorhabdovirus</i> *	potato yellow dwarf virus (PYDV)
	<i>Rice yellow stunt nucleorhabdovirus</i>	rice yellow stunt virus (RYSV)
		rice transitory yellowing virus (RTYV)
	<i>Sonchus yellow net nucleorhabdovirus</i>	sonchus yellow net virus (SYNV)
	<i>Sowthistle yellow vein nucleorhabdovirus</i>	sowthistle yellow vein virus (SYVV)
	<i>Taro vein chlorosis nucleorhabdovirus</i>	taro vein chlorosis virus (TaVCV)
<i>Perhabdovirus</i>	<i>Anguillid perhabdovirus</i>	eel virus European X (EVEX)
	<i>Perch perhabdovirus</i> *	perch rhabdovirus (PRV)
	<i>Sea trout perhabdovirus</i>	lake trout rhabdovirus (LTRV)
<i>Sigmavirus</i>	<i>Drosophila affinis sigmavirus</i>	<i>Drosophila affinis</i> sigmavirus (DAffSV)
	<i>Drosophila ananassae sigmavirus</i>	<i>Drosophila ananassae</i> sigmavirus (DAAnaSV)
	<i>Drosophila immigrans sigmavirus</i>	<i>Drosophila immigrans</i> sigmavirus (DImmSV)
	<i>Drosophila melanogaster sigmavirus</i> *	<i>Drosophila melanogaster</i> sigmavirus (DMelSV)
	<i>Drosophila obscura sigmavirus</i>	<i>Drosophila obscura</i> sigmavirus (DObsSV)
	<i>Drosophila tristis sigmavirus</i>	<i>Drosophila tristis</i> sigmavirus (DTriSV)
	<i>Muscina stabulans sigmavirus</i>	<i>Muscina stabulans</i> sigmavirus (MStaSV)

Table 1 continued

Genus	Species	Virus (abbreviation)
<i>Sprivirus</i>	<i>Carp sprivirus</i> *	spring viremia of carp virus (SVCV)
	<i>Pike fry sprivirus</i>	grass carp rhabdovirus (GrCRV)
		pike fry rhabdovirus (PFRV)
		Tench rhabdovirus (TenRV)
<i>Tibrovirus</i>	<i>Coastal Plains tibrovirus</i>	Coastal Plains virus (CPV)
	<i>Tibrogargan tibrovirus</i> *	Bivens Arm virus (BAV)
		Tibrogargan virus (TIBV)
<i>Tupavirus</i>	<i>Durham tupavirus</i> *	Durham virus (DURV)
	<i>Tupaia tupavirus</i>	tupaia virus (TUPV)
<i>Varicosavirus</i>	<i>Lettuce big-vein associated varicosavirus</i> *	lettuce big-vein associated virus (LBVaV) ⁿ
<i>Vesiculovirus</i>	<i>Alagoas vesiculovirus</i>	vesicular stomatitis Alagoas virus (VSAV)
	<i>Carajas vesiculovirus</i>	Carajás virus (CJSV)
	<i>Chandipura vesiculovirus</i>	Chandipura virus (CHPV)
	<i>Cocal vesiculovirus</i>	Cocal virus (COCV)
	<i>Indiana vesiculovirus</i> *	vesicular stomatitis Indiana virus (VSIV)
	<i>Isfahan vesiculovirus</i>	Isfahan virus (ISFV)
	<i>Maraba vesiculovirus</i>	Maraba virus (MARAV)
	<i>New Jersey vesiculovirus</i>	vesicular stomatitis New Jersey virus (VSNJV)
	<i>Piry vesiculovirus</i>	Piry virus (OIRYV)
	Unassigned	<i>Flanders virus</i>
<i>Ngaingan virus</i>		Ngaingan virus (NGAV)
<i>Wongabel virus</i>		Wongabel virus (WONV)
Family <i>Sunviridae</i>		
<i>Sunshinevirus</i>	<i>Reptile sunshinevirus 1</i> *	Sunshine Coast virus (SunCV)
Unassigned		
<i>Anphevirus</i>	<i>Xincheng anphevirus</i> *	Xīnchéng mosquito virus (XcMV)
<i>Arlivirus</i>	<i>Lishi arlivirus</i> *	Líshí spider virus 2 (LsSV-2)
<i>Chengtivirus</i>	<i>Tacheng chengtivirus</i> *	Tǎchéng tick virus 6 (TcTV-6)
<i>Crustavirus</i>	<i>Wenzhou crustavirus</i> *	Wēnzhōu crab virus 1 (WzCV-1)
<i>Wastrivirus</i>	<i>Sanxia wastrivirus</i> *	Sānxiá water strider virus 4 (SxWSV-4)

Listed are all mononegaviruses that have been classified into species. Asterisks denote type species

^a Includes: Newcastle disease virus (NDV) and pigeon paramyxovirus

^b Synonym: anaconda paramyxovirus

^c Synonym: GH-M74a virus

^d Abbreviation as recently introduced in [26]

^e Historically, an isolate from a samango monkey (*Cercopithecus mitis*) in 1963 was long classified as a distinct species called simian agent 10 (SA-10), but was shown later to be HPIV-3. SA-10 was sometimes called SV-10

^f Synonym: murine parainfluenza virus 1

^g Synonym: bat paramyxovirus

^h Synonym: simian virus 5

ⁱ Synonym: porcine rubulavirus

^j Synonyms: avian pneumovirus, turkey rhinotracheitis virus

^k Synonyms: citrus leprosis virus nuclear type, citrus necrotic spot virus

^l Synonym Tzipori virus

^m Synonyms: Egtved virus, Paralichthys olivaceus rhabdovirus

ⁿ Synonym: tobacco stunt virus

Latinized binomial species name format [29] was applied throughout the family (Table 1).

A summary of the current, ICTV-accepted taxonomy of the order *Mononegavirales* is presented in Table 1.

Acknowledgments We thank Laura Bollinger (NIH/NIAD Integrated Research Facility at Fort Detrick, Frederick, MD, USA) for critically editing the manuscript.

Thomas Briese, Ralf Dürrwald, Masayuki Horie, Jens H. Kuhn, Norbert Nowotny, Susan L. Payne, Dennis Rubbenstroth, Martin Schwemmler, Keizo Tomonaga: The members of the International Committee on Taxonomy of Viruses (ICTV) *Bornaviridae* Study Group; Gaya K. Amarasinghe, Christopher F. Basler, Sina Bavari, Alexander Bukreyev, Kartik Chandran, Olga Dolnik, John M. Dye, Hideki Ebihara, Pierre Formenty, Roger Hewson, Gary P. Kobinger, Jens H. Kuhn, Eric M. Leroy, Elke Mühlberger, Sergey V. Netesov, Jean L. Patterson, Janusz T. Paweska, Sophie J. Smither, Ayato Takada, Jonathan S. Towner, Viktor E. Volchkov, Victoria Wahl-Jensen: The members of the ICTV *Filoviridae* Study Group; Ralf G. Dietzgen, Andrew J. Easton, Jens H. Kuhn, Gael Kurath, Norbert Nowotny, Bertus K. Rima, Dennis Rubbenstroth, Nikos Vasilakis, Peter J. Walker: The members of the ICTV *Mononegavirales* Study Group; Ralf G. Dietzgen, Leslie L. Domier, Elodie Ghedin, Dàohóng Jiāng, Jens H. Kuhn, Nikos Vasilakis, David Wang: The members of the ICTV *Nyamiviridae* Study Group; Peter L. Collins, Andrew J. Easton, Ron A. M. Fouchier, Gael Kurath, Robert A. Lamb, Andrea Maisner, Rick E. Randall, Bertus K. Rima, Paul Rota, Lin-Fa Wang: The members of the ICTV *Paramyxoviridae* Study Group; Kim R. Blasdel, Charles H. Calisher, Ralf G. Dietzgen, Hideki Kondo, Gael Kurath, Ben Longdon, David M. Stone, Robert B. Tesh, Noël Tordo, Nikos Vasilakis, Peter J. Walker, Anna E. Whitfield: The members of the ICTV *Rhabdoviridae* Study Group.

Compliance with ethical standards

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the US Department of the Army, the US Department of Defense, the US Department of Health and Human Services, the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) or of the institutions and companies affiliated with the authors. In no event shall any of these entities have any responsibility or liability for any use, misuse, inability to use, or reliance upon the information contained herein. The US departments do not endorse any products or commercial services mentioned in this publication.

Funding This work was supported in part through Battelle Memorial Institute's prime contract with the US National Institute of Allergy and Infectious Diseases (NIAID) under Contract No. HHSN272200700016I. A subcontractor to Battelle Memorial Institute who performed this work is: J. H. K., an employee of Tunnell Government Services, Inc. This work was also funded in part under Contract No. HSHQDC-07-C-00020 awarded by DHS S&T for the management and operation of the National Biodefense Analysis and Countermeasures Center (NBACC), a Federally Funded Research and Development Center (V. W.-J.); and National Institutes of Health (NIH) contract HHSN272201000040I/HHSN27200004/D04 (N. V., R. B. T.). Y. B. was supported by the Intramural Research Program of the NIH, National Library of Medicine.

Conflict of interest The authors have no conflicts of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

- Adams MJ, Lefkowitz EJ, King AM, Carstens EB (2014) Ratification vote on taxonomic proposals to the International Committee on Taxonomy of Viruses (2014). *Arch Virol* 159:2831–2841
- Adams MJ, Lefkowitz EJ, King AM, Bamford DH, Breitbart M, Davison AJ, Ghabrial SA, Gorbalenya AE, Knowles NJ, Krell P, Lavigne R, Prangishvili D, Sanfacon H, Siddell SG, Simmonds P, Carstens EB (2015) Ratification vote on taxonomic proposals to the International Committee on Taxonomy of Viruses (2015). *Arch Virol* 160:1837–1850
- Bejerman N, Giolitti F, de Breuil S, Trucco V, Nome C, Lenardon S, Dietzgen RG (2015) Complete genome sequence and integrated protein localization and interaction map for alfalfa dwarf virus, which combines properties of both cytoplasmic and nuclear plant rhabdoviruses. *Virology* 483:275–283
- Bishop DHL, Pringle CR (1995) Order *Mononegavirales*. In: Murphy FA, Fauquet CM, Bishop DHL, Ghabrial SA, Jarvis AW, Martelli GP, Mayo MA, Summers MD (eds) *Virus taxonomy—Sixth Report of the International Committee on Taxonomy of Viruses/Arch Virol Suppl* 10. Springer, Vienna, pp 265–267
- Briand FX, Henry A, Massin P, Jestin V (2012) Complete genome sequence of a novel avian paramyxovirus. *J Virol* 86:7710
- Dietzgen RG, Kuhn JH, Clawson AN, Freitas-Astúa J, Goodin MM, Kitajima EW, Kondo H, Wetzel T, Whitfield AE (2014) *Dichorhavirus*: a proposed new genus for *Brevipalpus* mite-transmitted, nuclear, bacilliform, bipartite, negative-strand RNA plant viruses. *Arch Virol* 159:607–619
- Drexler JF, Cormann VM, Müller MA, Maganga GD, Vallo P, Binger T, Gloza-Rausch F, Cottontail VM, Rasche A, Yordanov S, Seebens A, Knörnschild M, Oppong S, Adu Sarkodie Y, Pongombo C, Lukashev AN, Schmidt-Chanasit J, Stöcker A, Borges Carneiro AJ, Erbar S, Maisner A, Fronhoffs F, Buettner R, Kalko EKV, Kruppa T, Franke CR, Kallies R, Yandoko ERN, Herler G, Reusken C, Hassanin A, Krüger DH, Matthee S, Ulrich RG, Leroy EM, Drosten C (2012) Bats host major mammalian paramyxoviruses. *Nat Commun* 3:796
- Easton AJ, Pringle CR (2011) Order *Mononegavirales*. In: King AMQ, Adams MJ, Carstens EB, Lefkowitz EJ (eds) *Virus taxonomy—Ninth Report of the International Committee on Taxonomy of Viruses*. Elsevier/Academic Press, London, pp 653–657
- Guo J, Tizard I (2015) The genome sequence of parrot bornavirus 5. *Virus Genes* 51:430–433
- Hyndman TH, Marschang RE, Wellehan JF Jr, Nicholls PK (2012) Isolation and molecular identification of Sunshine virus, a novel paramyxovirus found in Australian snakes. *Infect Genet Evol* 12:1436–1446
- Kuhn JH, Bekal S, Cai Y, Clawson AN, Domier LL, Herrel M, Jahrling PB, Kondo H, Lambert KN, Mihindukulasuriya KA, Nowotny N, Radoshitzky SR, Schneider U, Staeheli P, Suzuki N, Tesh RB, Wang D, Wang L-F, Dietzgen RG (2013) *Nyamiviridae*: proposal for a new family in the order *Mononegavirales*. *Arch Virol* 158:2209–2226
- Kuhn JH, Dürrwald R, Bào Y, Briese T, Carbone K, Clawson AN, deRisi JL, Garten W, Jahrling PB, Kolodziejek J, Rubbenstroth D, Schwemmler M, Stenglein M, Tomonaga K, Weissenböck H, Nowotny N (2015) Taxonomic reorganization of the family *Bornaviridae*. *Arch Virol* 160:621–632
- Kumar S, Collins PL, Samal SK (2010) Identification of simian agent 10 as human parainfluenza virus type 3 suggests transmission of a human virus to an African monkey. *J Virol* 84:13068–13070
- Lau SK, Woo PC, Wu Y, Wong AY, Wong BH, Lau CC, Fan RY, Cai JP, Tsoi HW, Chan KH, Yuen KY (2013) Identification

- and characterization of a novel paramyxovirus, porcine parainfluenza virus 1, from deceased pigs. *J Gen Virol* 94:2184–2190
15. Li CX, Shi M, Tian JH, Lin XD, Kang YJ, Chen LJ, Qin XC, Xu J, Holmes EC, Zhang YZ (2015) Unprecedented genomic diversity of RNA viruses in arthropods reveals the ancestry of negative-sense RNA viruses. *Elife* 4:e05378
 16. Liu L, Xie J, Cheng J, Fu Y, Li G, Yi X, Jiang D (2014) Fungal negative-stranded RNA virus that is related to bornaviruses and nyaviruses. *Proc Natl Acad Sci USA* 111:12205–12210
 17. Marsh GA, de Jong C, Barr JA, Tachedjian M, Smith C, Middleton D, Yu M, Todd S, Foord AJ, Haring V, Payne J, Robinson R, Broz I, Crameri G, Field HE, Wang LF (2012) Cedar virus: a novel henipavirus isolated from Australian bats. *PLoS Pathog* 8:e1002836
 18. Marton S, Bányai K, Gál J, Ihász K, Kugler R, Lengyel G, Jakab F, Bakonyi T, Farkas SL (2015) Coding-complete sequencing classifies parrot bornavirus 5 into a novel virus species. *Arch Virol* 160:2763–2768
 19. Miller PJ, Afonso CL, Spackman E, Scott MA, Pedersen JC, Senne DA, Brown JD, Fuller CM, Uhart MM, Karesh WB, Brown IH, Alexander DJ, Swayne DE (2010) Evidence for a new avian paramyxovirus serotype 10 detected in rockhopper penguins from the Falkland Islands. *J Virol* 84:11496–11504
 20. Pringle CR (1991) Order *Mononegavirales*. In: Francki RIB, Fauquet CM, Knudson DL, Brown F (eds) Classification and nomenclature of viruses—Fifth Report of the International Committee on Taxonomy of Viruses/*Arch Virol Suppl* 2. Springer, Vienna, pp 239–241
 21. Pringle CR, Alexander DJ, Billeter MA, Collins PL, Kingsbury DW, Lipkind MA, Nagai Y, Orvell C, Rima B, Rott R, ter Meulen V (1991) The order *Mononegavirales*. *Arch Virol* 117:137–140
 22. Pringle CR (1996) Virus taxonomy 1996—a bulletin from the Xth International Congress of Virology in Jerusalem. *Arch Virol* 141:2251–2256
 23. Pringle CR (1997) The order *Mononegavirales*—current status. *Arch Virol* 142:2321–2326
 24. Pringle CR (2000) Order *Mononegavirales*. In: van Regenmortel MHV, Fauquet CM, Bishop DHL, Carstens EB, Estes MK, Lemon SM, Maniloff J, Mayo MA, McGeoch DJ, Pringle CR, Wickner RB (eds) Virus taxonomy—Seventh Report of the International Committee on Taxonomy of Viruses. Academic Press, San Diego, pp 525–530
 25. Pringle CR (2005) Order *Mononegavirales*. In: Fauquet CM, Mayo MA, Maniloff J, Desselberger U, Ball LA (eds) Virus taxonomy—Eighth Report of the International Committee on Taxonomy of Viruses. Elsevier/Academic Press, San Diego, pp 609–614
 26. Sharp CR, Nambulli S, Acciardo AS, Rennick LJ, Drexler JF, Rima BK, Williams T, Duprex WP (2016) Chronic infection of domestic cats with feline morbillivirus, United States. *Emerg Infect Dis* 22:760–762
 27. Stenglein MD, Leavitt EB, Abramovitch MA, McGuire JA, DeRisi JL (2014) Genome sequence of a bornavirus recovered from an African garter snake (*Elapsoidea loveridgei*). *Genome Announc* 2:e00779-14
 28. Terregino C, Aldous EW, Heidari A, Fuller CM, De Nardi R, Manvell RJ, Beato MS, Shell WM, Monne I, Brown IH, Alexander DJ, Capua I (2013) Antigenic and genetic analyses of isolate APMV/wigeon/Italy/3920-1/2005 indicate that it represents a new avian paramyxovirus (APMV-12). *Arch Virol* 158:2233–2243
 29. Van Regenmortel MH, Burke DS, Calisher CH, Dietzgen RG, Fauquet CM, Ghabrial SA, Jahrling PB, Johnson KM, Holbrook MR, Horzinek MC, Keil GM, Kuhn JH, Mahy BW, Martelli GP, Pringle C, Rybicki EP, Skern T, Tesh RB, Wahl-Jensen V, Walker PJ, Weaver SC (2010) A proposal to change existing virus species names to non-Latinized binomials. *Arch Virol* 155:1909–1919
 30. Woo PC, Lau SK, Wong BH, Fan RY, Wong AY, Zhang AJ, Wu Y, Choi GK, Li KS, Hui J, Wang M, Zheng BJ, Chan KH, Yuen KY (2012) Feline morbillivirus, a previously undescribed paramyxovirus associated with tubulointerstitial nephritis in domestic cats. *Proc Natl Acad Sci USA* 109:5435–5440
 31. Wu Z, Yang L, Yang F, Ren X, Jiang J, Dong J, Sun L, Zhu Y, Zhou H, Jin Q (2014) Novel henipa-like virus, Mojiang paramyxovirus, in rats, China, 2012. *Emerg Infect Dis* 20:1064–1066