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ICTV Virus Taxonomy Profile: *Kolmioviridae* 2024

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Abstract

Kolmioviridae is a family for negative-sense RNA viruses with circular, viroid-like genomes of about 1.5–1.7 kb that are maintained in mammals, amphibians, birds, fish, insects and reptiles. Deltaviruses, for instance, can cause severe hepatitis in humans. Kolmiovirids encode delta antigen (DAg) and replicate using host-cell DNA-directed RNA polymerase II and ribozymes encoded in their genome and antigenome. They require evolutionary unrelated helper viruses to provide envelopes and incorporate helper virus proteins for infectious particle formation. This is a summary of the International Committee on Taxonomy of Viruses (ICTV) Report on the family *Kolmioviridae*, which is available at ictv.global/report/kolmioviridae.

Table 1. Characteristics of members of the family *Kolmioviridae*

Example:	hepatitis D virus 1 (AF104263), species <i>Deltavirus italicense</i> , genus <i>Deltavirus</i>
Virion	Spherical virions (36–43 nm in diameter) with an outer envelope containing envelope proteins derived from a helper virus and an inner ribonucleoprotein consisting of genomic RNA and a nucleocapsid protein (delta antigen; DAg) that is encoded by the genomic RNA and may occur in two isoforms
Genome	Rod-like ribozyme-containing negative-sense, covalently closed, circular RNA (cccRNA) of about 1.5–1.7 kb
Replication	RNA-directed RNA synthesis by host-cell DNA-directed RNA polymerase II through a double rolling circle mechanism, and autocatalytic cleavage/ligation via encoded genomic and antigenomic ribozymes and re-cyclization in the host-cell nucleus
Translation	mRNA-based translation of DAg (in some cases including an isoform thereof)
Host range	Mammals, amphibians, birds, fish, insects and reptiles
Taxonomy	Realm <i>Ribozyviria</i> ; the family includes >7 genera and >14 species

VIRION

Kolmiovirions are spherical with a lipid envelope containing envelope proteins obtained from an evolutionarily unrelated helper virus (Table 1, Fig. 1). Virions contain a ribonucleoprotein (RNP) complex consisting of distinct isoforms of delta antigen (DAg) that are encoded in and closely associate with deltavirus genomic and antigenomic RNAs [1, 2].

GENOME

Kolmiovirids have a viroid-like, ribozyme-containing, negative-sense, covalently closed circular RNA (cccRNA) genome of about 1.5–1.7 kb (Fig. 2) that forms a rod-like structure through its high degree of self-complementarity. The genome encodes a single protein, DAg, which in some cases occurs in two isoforms [1–8].

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Abbreviations: cccRNA, covalently closed, circular RNA; DAg, delta antigen; HBV, hepatitis B virus; L-DAg, S-DAg, large and small delta antigen; L-HBsAg, M-HBsAg, S-HBsAg, large, middle and small hepatitis B virus surface antigen; RNP, ribonucleoprotein.

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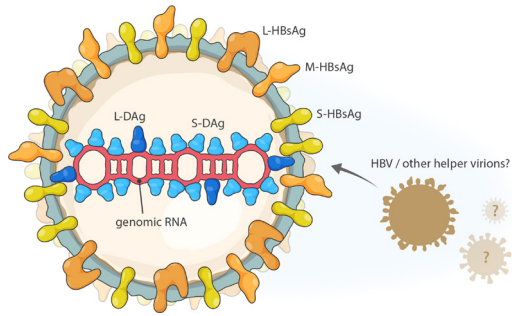


Fig. 1. Schematic of hepatitis D virus 1 particles. L-DAg, S-DAg: large and small delta antigen; L-HBsAg, M-HBsAg, S-HBsAg: large, middle and small HBV surface antigen; HBV: hepatitis B virus.

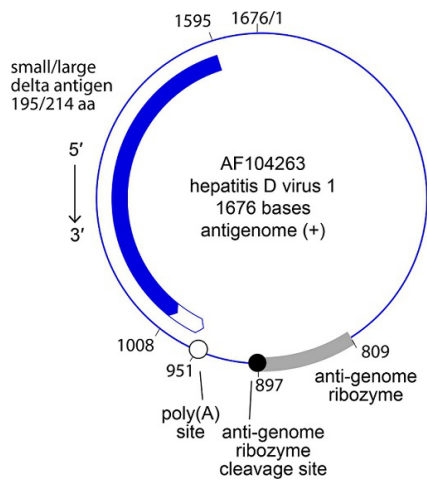


Fig. 2. Antigenome organization of hepatitis D virus 1. Nucleotide numbering according to that for the (complementary) genome.

REPLICATION

Kolmiovirion cell entry is mediated by interaction with cell-surface receptors and envelope proteins that are obtained from helper viruses. Membrane fusion releases the RNP into the cytosol, from where it migrates to the cell nucleus where RNA-directed RNA genome and antigenome synthesis is mediated by host-cell DNA-directed RNA polymerase II through a double rolling circle mechanism; genome- and antigenome-encoded

ribozymes catalyse autocatalytic cleavage of concatenated progeny genomes and ligation/recyclization in the nucleus. DAg isoforms serve as nucleoproteins and regulate replication and packaging [1, 2].

PATHOGENICITY

Deltaviruses cause disease in humans, typically in association with the evolutionarily unrelated hepatitis B virus (HBV, family *Hepadnaviridae*). Coinfection causes hepatitis D, the most severe of WHO-classified viral hepatitis [1, 2].

TAXONOMY

Current taxonomy: ictv.global/taxonomy. Kolmiovirids (realm *Ribozyviria*) are most closely related to viroids and related mobile genetic elements. Kolmiovirids share at least two of the following characteristics: (i) enveloped virions; (ii) circular negative-sense RNA genome containing ribozymes and encoding a DAg homolog; (iii) require an evolutionarily unrelated helper virus for assembly of infectious virions.

RESOURCES

Full ICTV Report on the family *Kolmioviridae*: www.ictv.global/report/kolmioviridae.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

References

- Asselah T, Rizzetto M. Hepatitis D virus infection. *N Engl J Med* 2023;389:58–70.
- Dandri M, Volmari A, Lütgehetmann M. The hepatitis delta virus and chronic hepatitis D. *J Hepatol* 2022;77:1448–1450.
- Chang W-S, Pettersson JH-O, Le Lay C, Shi M, Lo N, et al. Novel hepatitis D-like agents in vertebrates and invertebrates. *Virus Evol* 2019;5:vez021.
- Hetzel U, Szivovics L, Smura T, Prähauser B, Vapalahti O, et al. Identification of a novel deltavirus in boa constrictors. *mBio* 2019;10:00014–00019.
- Wille M, Netter HJ, Littlejohn M, Yuen L, Shi M, et al. A divergent hepatitis D-like agent in birds. *Viruses* 2018;10:e0720.
- Paraskevopoulou S, Pirzer F, Goldmann N, Schmid J, Corman VM, et al. Mammalian deltavirus without hepadnavirus coinfection in the neotropical rodent *Proechimys semispinosus*. *Proc Natl Acad Sci U S A* 2020;117:17977–17983.
- Bergner LM, Orton RJ, Broos A, Tello C, Becker DJ, et al. Diversification of mammalian deltaviruses by host shifting. *Proc Natl Acad Sci U S A* 2021;118:e2019907118.
- Lucifora J, Delphin M. Current knowledge on hepatitis delta virus replication. *Antiviral Res* 2020;179:104812.