Tristromaviridae

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Summary

*Tristromaviridae* is a family of viruses with linear, double-stranded DNA genomes of 16–18 kbp (Table 1. *Tristromaviridae*). The flexible, filamentous virions (400 ± 20 nm × 30 ± 3 nm) consist of a lipid envelope and an inner core constructed from two structural units: a rod-shaped helical nucleocapsid and a nucleocapsid-encompassing matrix protein layer. Tristromaviruses are lytic and infect hyperthermophilic archaea of the order Thermoproteales.

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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical member:</td>
<td><em>Pyrobaculum filamentous virus 1</em> (KU307456), species <em>Pyrobaculum filamentous virus 1</em>, genus <em>Alphatristromavirus</em></td>
</tr>
<tr>
<td>Virion</td>
<td>Filamentous, flexible (400 ± 20 nm × 30 ± 3 nm) particle consisting of a nucleoprotein core covered by a matrix protein layer and enveloped with a lipid membrane; bundles of thin filaments are attached to both ends</td>
</tr>
<tr>
<td>Genome</td>
<td>Linear, double-stranded DNA genomes of 16–18 kbp</td>
</tr>
<tr>
<td>Replication</td>
<td>Viruses are lytic; virions are released by the rupture of the host cell envelope</td>
</tr>
<tr>
<td>Translation</td>
<td>Not characterized</td>
</tr>
<tr>
<td>Host range</td>
<td>Hyperthermophilic archaea of the order Thermoproteales</td>
</tr>
<tr>
<td>Taxonomy</td>
<td>One genus, two species</td>
</tr>
</tbody>
</table>

Virion

Morphology

The virions are filamentous, 400 ± 20 × 32 ± 3 nm, and contain a lipid-containing envelope and an inner core consisting of two structural units: (i) a rod-shaped helical nucleocapsid, formed of two major virion proteins (VP1 and VP2), and (ii) a nucleocapsid-encompassing protein (VP3) sheath (Table 1. *Tristromaviridae*, Figure 1. *Tristromaviridae* (Rensen et al., 2016). The sheath layer is sandwiched between the nucleocapsid and the envelope, akin to the matrix protein layer found in certain eukaryotic negative-sense RNA viruses, e.g. members of the *Filoviridae* (King et al., 2012). Filamentous viruses with dsDNA genomes are thus far exclusive to hosts in the domain Archaea (Prangishvili et al., 2017).
Physicochemical and physical properties

Non-ionic detergents, such as Triton X-100 and Nonidet P-40, dissociate virions into viral cores, containing the dsDNA genome and the DNA-binding nucleocapsid proteins, and the viral envelopes containing lipids. Mild treatment with Tween-20 causes partial detachment of the envelope from the nucleocapsid but not its complete removal. The virions are completely degraded when treated with 0.1% SDS. Treatment with ethanol (50% vol/vol) does not affect the integrity of the virions but results in their conversion into cane-shaped particles. Virions appear to be sensitive to mechanical stress and can be partially disrupted in the course of purification and concentration (Rensen et al., 2016).

Nucleic acid

The linear dsDNA genome of Pyrobaculum filamentous virus 1 (PFV1) is 17,714 bp, includes 60 bp terminal inverted repeats, and is predicted to encode 39 proteins (Figure 2. Tristromaviridae), most of which do not show similarities to sequences in public databases (Krupovic et al., 2018). The genome has a G+C content of 45.4%, which is considerably lower than that of the host genome (~55%).

Proteins

PFV1 virions contain three major capsid proteins, VP1, VP2, and VP3, with molecular masses of 14 kDa, 14 kDa, and 18 kDa, respectively, and at least five minor proteins with molecular masses in the range of 11–30 kDa (Figure 2. Tristromaviridae). The proteins VP1 and VP2 bind the viral dsDNA and form the nucleoprotein filament. The highly hydrophobic 18 kDa protein, VP3, forms a nucleocapsid-encompassing protein sheath and is glycosylated (Figure 1. Tristromaviridae) (Rensen et al., 2016). The virions of the only other known tristromavirus, Thermoproteus tenax virus 1 (TTV1; Figure 3. Tristromaviridae), also include three major structural proteins, but only one of these, namely TP3, is shared with PFV1. Although some of the minor structural proteins of PFV1 have homologs in the TTV1 genome (Figure 2. Tristromaviridae), they have not been identified in TTV1 virions (Janekovic et al., 1983). Notably, one of the two major nucleocapsid proteins of TTV1, protein TP1, has evolved from a truncated Cas4-like nuclease (Krupovic et al., 2015). The gene for the Cas4-like nuclease is intact in the PFV1 genome (Figure 2. Tristromaviridae).
Figure 3. *Tristromaviridae*. Electron micrograph of intact and partially deteriorated virions of negatively-stained Thermoproteus tenax virus 1, stained with 2% uranyl acetate. Scale bar, 100 nm.

Lipids

The envelope of the virion contains lipids derived from the pool of host lipids: glycerol dibiphytanyl glycerol tetraether lipids and small amounts of the glycerol trialkyl glycerol tetraether lipids (Rensen et al., 2016).

Carbohydrates

The sheath protein VP3 of PFV1 has been shown to be glycosylated but the exact structure of the glycan remains unknown (Rensen et al., 2016).

Genome organization and replication

The PFV1 genome is predicted to encode 39 proteins that are larger than 40 amino acids (Figure 2. *Tristromaviridae*) (Rensen et al., 2016). The genes are tightly arranged and occupy 93.1% of the genome. All except one of the genes are encoded on the same strand. Thirty-six genes use AUG as a start codon. Ten of the PFV1 genes were predicted to encode proteins with one or more transmembrane domains. Sequence analyses allowed the assignment of putative functions to less than a quarter of all PFV1 genes (Krupovic et al., 2018). Five of them were predicted to be involved in carbohydrate metabolism, one encodes a Cas4-like nuclease, and others represent a ferritin protein and a putative trypsin-like serine protease (Figure 2. *Tristromaviridae*).

Nine gene products of PFV1 share significant sequence similarity with proteins encoded in the partially sequenced genome of the virus TTV1 (Neumann et al., 1989) (Figure 2. *Tristromaviridae*). Two of these genes are split in TTV1 when compared to PFV1.

Biology

The virus PFV1 was isolated from its host, obtained from a hot spring (87–93 °C, pH 6) in Pozzuoli, Italy (Rensen et al., 2016). The host range is limited to members of the hyperthermophilic archaea from the genus *Pyrobaculum* (order Thermoproteales). The virus TTV1 infects *Thermoproteus tenax* (genus *Thermoproteus*, order Thermoproteales) and was isolated with its host from a mud hole of 93°C, pH 6 at Krafja, Iceland (Janevovic et al., 1983). PFV1 binds to the host cell via interaction of the terminal protrusions of the virion with the host piliform appendages. The infection leads to cell lysis. Mature virions appear to assemble in the host cell lumen prior to release, which coincides with the rupture of the host cell envelope. The virus does not encode identifiable DNA and RNA polymerases and is likely to depend on the host machineries for genome replication and transcription.

Derivation of names

*Tristroma*: from Greek *tria* for three and *stroma* for a layer
TTV1 was originally assigned to the family *Lipothrixviridae* (genus *Alphalipothrixvirus*) based on its overall morphology and the presence of the external envelope. However, since subsequent comparative genomics analysis has shown that TTV1 does not share any homologous genes with other members of the *Lipothrixviridae*, the virus has been reclassified into the family *Tristromaviridae* (Rensen et al., 2016).
Genus: Alphatristromavirus

Since only one genus (*Alphatristromavirus*) is currently recognized in the family *Tristromaviridae*, the family description above corresponds to the genus description. For clarity, the additional information that can be found on the genus page is also presented below.

Species demarcation criteria

Species demarcation within this genus is based on the differences in the host range and gene content. There are too few representatives at the moment to provide more detailed demarcation criteria.

Member species

<table>
<thead>
<tr>
<th>Exemplar isolate of the species</th>
<th>Species</th>
<th>Virus name</th>
<th>Isolate</th>
<th>Accession number</th>
<th>RefSeq number</th>
<th>Available sequence</th>
<th>Virus Abbrev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Pyrobaculum filamentous virus</td>
<td>Pyrobaculum filamentous virus 1</td>
<td>1</td>
<td>Z20677400</td>
<td>KU307456</td>
<td>NC_029548</td>
<td>Complete genome</td>
<td>PFV1</td>
</tr>
<tr>
<td>★ Thermoproteus tenax virus 1</td>
<td>Thermoproteus tenax virus 1</td>
<td>KRA1</td>
<td>X14855</td>
<td>X14855</td>
<td>NC_038931</td>
<td>Partial genome</td>
<td>TTV1</td>
</tr>
</tbody>
</table>

Virus names, the choice of exemplar isolates, and virus abbreviations, are not official ICTV designations.
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Resources: Tristromaviridae

Sequence alignments and tree files:

None currently associated with this report.
References: Tristromaviridae


Citation: *Tristromaviridae*

A summary of this ICTV Report chapter has been published as an ICTV Virus Taxonomy Profile article in the Journal of General Virology, and should be cited when referencing this online chapter as follows:


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