EPPO Datasheet: *Tymovirus latandigenum*

Last updated: 2023-10-18

This datasheet covers both *Andean potato latent virus* & *Andean potato mild mosaic virus.*

IDENTITY

Preferred name: *Tymovirus latandigenum*
Taxonomic position: Viruses and viroids: Riboviria: Orthornavirae: Kitrinoviricota: Alsuviricetes: Tymovirales: Tymoviridae
Other scientific names: *APLV, Andean potato latent tymovirus, Andean potato latent virus, Potato Andean latent tymovirus, Potato Andean latent virus*
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EPPO Categorization: A1 list
view more categorizations online...
EU Categorization: Quarantine pest ((EU) 2019/2072 Annex II A)
EPPO Code: APLV00

Notes on taxonomy and nomenclature

Andean potato latent virus (APLV) named by Gibbs *et al*. (1966) was once considered to be a strain of the tymovirus species, *Eggplant mosaic virus* (EMV) (Gibbs & Harrison, 1969; 1973) but later sequence analysis showed it to be a distinct species. Historically, three major serological strain groups were recognized: CCC containing isolates Col-2 and Col-3; Col-Caj containing isolates Caj, Bo-14, Bo-15, Col, Col-4, Col-5, and Ec-1; and Hu containing isolates Ay, Bo-1 to Bo-12 (Fribourg *et al*., 1977; Koenig *et al*., 1979). Additionally, Kreuze *et al*. (2013) suggested the possibility of their being another strain group represented by APLV U isolated from ulluco (Lizarraga *et al*., 2001). However, based on the comparison of the complete genomic RNA sequences of Col and Hu isolates, APLV was separated into two species: APLV for the Col isolate (the original Colombian isolate of APLV described by Gibbs *et al*., 1966) and *Andean potato mild mosaic virus* (APMMV) for the Ay and Hu isolates (Kreuze *et al*., 2013; ICTV, 2022). Additionally, the other isolates (Bo-14, Bo-15, Caj, Col-2 – Col-5 and Ec-1) had coat protein (CP) aa sequence identities which were mostly above the species demarcation threshold of 90% suggested for tymoviruses (ICTV, 2011), indicating that they were isolates of APLV. Furthermore, these isolates only shared an average CP aa sequence identity of 59% with APMMV isolates. APMMV isolates were more closely related to EMV than to APLV (Kreuze *et al*., 2013).

The recent demarcation of species based on genome differences means that it is not always possible to determine from historical publications, where ELISA and biological tests were used to identify the virus, which of the two species (APLV or APMMV) the publications refer to. Therefore, this data sheet presents the information, when possible, with reference to isolates as described in the publications, recognizing that some of the data used may relate to APLV or APMMV or indeed other tymoviruses which have been misidentified as APLV because of their original identification according to ELISA and biological tests.

HOSTS

The principal natural host of APLV is potato (*Solanum tuberosum*) and tuber-forming *Solanum* species such as *Solanum acaule, S. chaucha, S. juzepczukii, S. phureja* and *S. stenotomum*. It has also been found infecting *Lepidium peruvianum*, which according to Meissner *et al.* (2015) is the cultivated form of *Lepidium meyenii* (maca, family Brassicaceae) (Alcazar *et al*., 2002, 2003; Kreuze *et al*., 2020), and *Ullucus tuberosus* (ulluco, family Basellaceae) (Lizarraga *et al*., 1996; 2001). However, the incidence of APLV in ulluco, determined by ELISA / biological tests and reported at incidences of 44% in the Andean region (Lizarraga *et al*., 1997) may have been over estimated: ulluco leaf samples, which were positive in ELISA for APLV were found, following high throughput sequencing (HTS) and genome analysis, not to have APLV or APMMV but two new tymoviruses, with the proposed

names Ullucus tymovirus-1 and Ullucus tymovirus-2. In a phylogenetic tree of tymoviruses, these new viruses were between APLV and APMMV (Fox *et al*., 2019). Furthermore, APLV isolate U from ulluco (Lizarraga *et al*., 1996) which was not detected in ELISA using antiserum raised to Hu and Caj-2 isolates, may represent a distantly related strain group (Kreuze *et al*., 2013) or a new virus. The presence of the same or closely related viruses infecting potato and Andean root crops is perhaps not surprising since they may be grown in the same field, in rotation with or may be intercropped with potato.

Experimentally, APLV isolate Caj and APMMV (formerly APLV isolates Ay and Hu) have been transmitted mechanically to species in the families Amaranthaceae, Chenopodiaceae, Cucurbitaceae and Solanaceae (Fribourg *et al.*, 1977) and the APLV Col isolate to species in Amaranthaceae, Chenopodiaceae and Solanaceae (Gibbs *et al.*, 1966).

Host list: *Capsicum sp.*, *Lepidium meyenii*, *Solanum acaule*, *Solanum chaucha*, *Solanum juzepczukii*, *Solanum phureja*, *Solanum stenotomum*, *Solanum tuberosum hybrids*, *Solanum tuberosum subsp. andigenum*, *Solanum tuberosum*, *Ullucus tuberosus*

GEOGRAPHICAL DISTRIBUTION

Historically, APLV has been reported as widespread in potato, in the Andean high-altitude regions of Bolivia, Colombia, Ecuador and Peru (Gibbs *et al*., 1966; Koenig *et al.*, 1979).

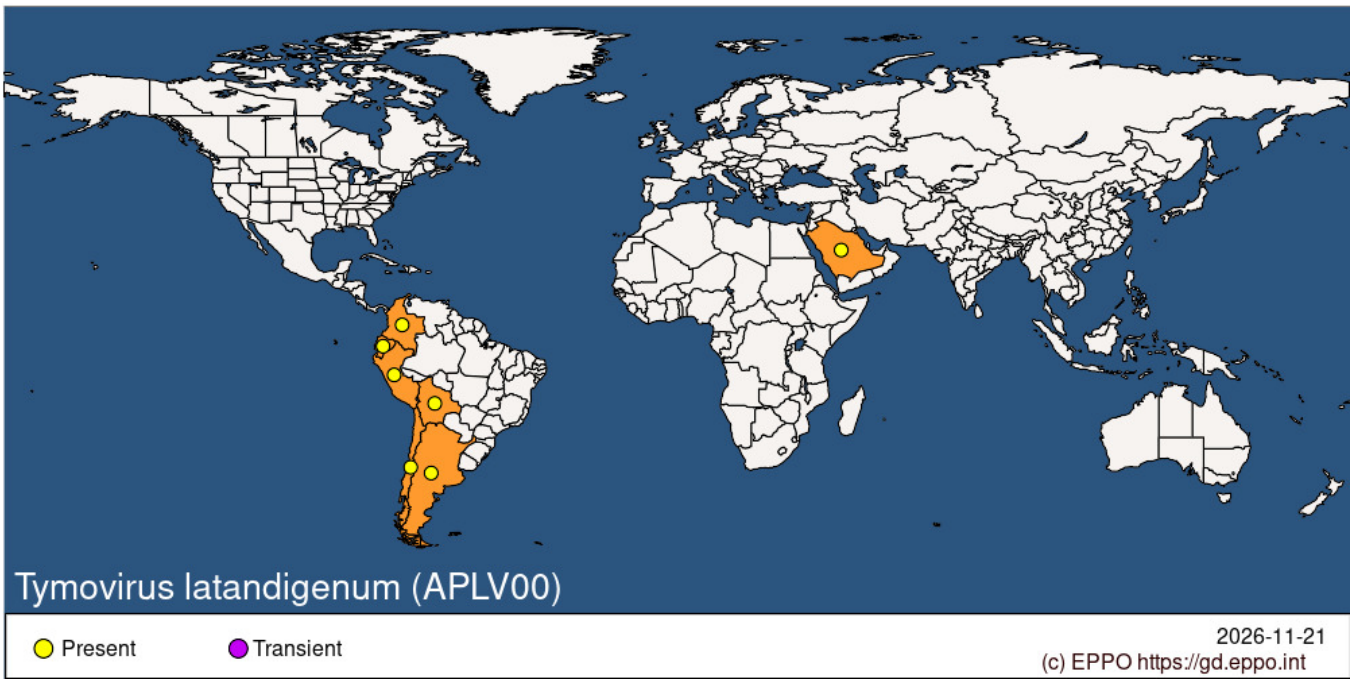
In the Sierra Central and Sierra Sur ranges of Peru, Bertschinger *et al*. (1990) reported 0.4% - 63% APLV viral incidence in *Solanum tuberosum* subsp. *andigena* cultivars. However, it now appears to be less common since in a recent survey, using HTS, it was found at incidences of 1% and 1.5% for APLV and APMMV respectively and at an incidence of 1% for new variants, potentially new tymovirus species (Fuentes *et al*., 2019; Kreuze *et al*., 2019).

In Bolivia, the most common viruses found in *S. tuberosum* subsp. *andigenum* cv. Huaycha in the department of Cochabamba, Quechua Andean region (2900–3380 metres above the sea level, masl) were *Potato virus X* (PVX), APLV, *Andean potato mottle virus* (APMoV) and *Potato virus Y* (PVY) with *Potato virus S* (PVS) and *Potato leafroll virus* (PLRV) found to a lesser extent (Garcia & Gandarillas, 1992). Recently, Coca Morante *et al*. (2021) found that APLV was the second and fourth most commonly detected virus respectively in the Quechua region (ranging from 0-25% incidence in different localities) and in the Aymara region (ranging from 0-38% incidence in different localities). However, APLV was not detected using ELISA in the departments of Cochabamba, La Paz, and Potosi when various wild stolon / tuber forming species, such as *Solanum acaule*, *S. brevicaule* and *S. microdontum,* were tested (Coca Morante & Ponce, 2021). Also it was not detected in eight communities in the Lope Mendoza area, 2950-3170 masl (Lope Mendoza, Escalante, Chullchunghani, Phuyuhuasi, Qhollu Mayu, Cuesta Punta, Vélez Rancho and Chaupi Rancho) (Coca Morante *et al*., 2023) suggesting that a new pattern of potato virus distribution with a possible reduction in APLV incidence was emerging, at least, for this Andean region.

In Chile a survey found APLV in 14% of the samples collected from the Valparaíso region, formerly known as the 5 th region (Saldias & Apablaza, 1984). Away from the Andean region, in Southern Chile on the Chiloé Archipelago, neither APLV or APMM were reported following testing of 98 potato samples by HTS (Pena Reyes, 2019).

A changing pattern and reduction in APLV incidence in potato may also be occurring in the Andean region of other countries due to increased awareness and testing. In Argentina APLV was not found infecting *S. tuberosum* cultivars and wild tuber forming *Solanum* spp. in the province of Jujuy, when tested by ELISA (Clausen *et al*., 2005). Similarly, in Colombia neither APLV or APMM were detected in potato fields (*Solanum tuberosum* and *S. phureja)* from Eastern Antioquia using HTS (Gutiérrez *et al.*, 2021).

For ulluco, APLV (APLV-U) has been found, based on testing using ELISA, in the *in vitro* germplasm collection of the International Potato Centre, in accessions originating from Argentina, Bolivia, Chile, Colombia, Ecuador and Peru (Lizarraga *et al*., 2001) but, with the exception of Peru, very little information on this virus in ulluco has been reported from these countries since this publication.



Asia: Saudi Arabia
South America: Argentina, Bolivia, Chile, Colombia, Ecuador, Peru

BIOLOGY

The main means of transmission is mechanically by contact (see Pathways for movement). Virus species in the genus *Tymovirus*, are typically beetle-transmitted in a semi-persistent manner (ICTV, 2011). In experiments using *Epitrix* spp., APLV was transmitted from infected to healthy *Datura stramonium*, and the closely related species APMMV was transmitted with low efficiency from infected *Datura stramonium* and *Nicotiana bigelovii* plants, to potato (Jones & Fribourg, 1977; reported as APLV Ay and APLV Hu in this publication), leading the authors to conclude that *Epitrix* spp. could only act as a natural vector when high populations were present. The virus (not known whether it was APLV or APMMV) was also transmitted at a low frequency through true potato seed (TPS) (Jones & Fribourg, 1977) although Jones (1982) was unable to confirm seed transmission perhaps because of high glasshouse temperatures during the experiment. APLV has been occasionally detected in TPS gene bank collections: in the Netherlands (Roenhorst & Verhoeven, 1998); and in Russia (see CABI datasheet for APLV) although the finding in the Netherlands was later changed to APMMV (EPPO, 2018). APLV Caj and APLV Hu (= APMMV) were also infrequently detected in pollen from flowers of infected potato plants and with no transmission from infected pollen to seed detected (Jones, 1982). Transmission to tubers appears to be erratic (Jones & Fribourg, 1981). APLV has been reported by Alcazar *et al.* (2003) to be transmitted by seed of maca (at a rate of 0.44%) supplied by farmers from the Peruvian province of Junin (4 100 masl), but whether APLV/APMMV may be spread by seed and pollen of other hosts has not been reported.

DETECTION AND IDENTIFICATION

For detection and identification also refer to EPPO Diagnostic Standard PM 7/132 *Andean potato latent virus* and *Andean potato mild mosaic virus* (EPPO, 2018).

Symptoms

Gibbs *et al.* (1966) gave the name ‘latent’ in APLV because under their glasshouse conditions, the Col isolate caused slight or no symptoms in plants of several British potato cultivars mechanically inoculated or grafted with infected plants. However, it is now known that symptoms may be produced, depending on virus strain, potato species/cultivar, whether it is a primary or secondary infection and climatic conditions. In the field, primary infections are often symptomless, but may cause mosaics and/or chlorotic netting of minor leaf veins (Jones &

Fribourg, 1981). This was particularly the case for the wild species in glasshouse experiments following mechanical inoculation (Fribourg *et al.*, 1977). Secondary infection usually caused symptoms in glasshouse experiments following mechanical inoculation, similar to those reported in the field for the Ay (=APMMV), Caj, and Hu (=APMMV) isolates: mild to severe mosaics, chlorotic netting of minor leaf veins necrotic flecking, leaf curling and leaf-tip necrosis (Fribourg *et al.*, 1977) sometimes with rugosity (Jones & Fribourg, 1981). In more recent experiments, Kreuze *et al.* (2013) found that potato cultivars infected with the APMMV (Hu isolate) raised under glasshouse were nearly always symptomless, or in rare cases showed mild mosaic, when in a single infection. A wide daily fluctuation in temperature, with particularly cold conditions, seeming to favour symptom expression in infected plants growing at high altitude. Severe symptoms are also induced in mixed infections with other potato viruses (Jones & Fribourg, 1978).
In ulluco it appears that no symptoms are produced (Lizarraga *et al*., 1996) but in maca dwarfism and chlorosis is associated with APLV infection (C Chuquillanqui, formerly CIP, Peru, personal communication, 2023).

Morphology

APLV (and APMMV) virions are isometric, non-enveloped and of about 30 nm in diameter. They sediment in two components: T, made up of non-infectious protein shells that contain little or no RNA (primarily subgenomic CP (coat protein) mRNA); and B, composed of intact nucleoprotein particles. The capsids of tymoviruses are made up of 20 hexameric and 12 pentameric subunits arranged in a T=3 icosahedron and the RNA appears to be at least partially ordered in an icosahedral arrangement in the centre of the protein shell. The genome is monopartite with linear, positive sense single-stranded RNA, 6.0–6.7 kb in size (ICTV, 2011).

Detection and inspection methods

Field inspection of potato plants and other host plants may enable detection of the virus if symptoms are produced; see EPPO Standard PM 3/71 General crop inspection procedure for potatoes (EPPO, 2007). However because symptoms depend on a range of factors (see section on Symptoms), virus testing should be done to confirm absence. APLV and APMMV are reliably detected in *in vitro* potato plants (4–6 weeks old and with stems of at least 5 cm length) and plants grown from infected tubers using indicator plants, serological and molecular methods. The reliability of testing tubers has not been reported.

Indicator plants

Indicator plants for use in quarantine testing are listed in PM 3/21 *Post-entry quarantine for potato* (EPPO, 2019a) and symptoms for some indicator plant species are described by Verhoeven & Roenhorst (2000). Symptoms on test plants, however, do not enable identification of the species. Mechanical inoculation of test plants is described in EPPO Standard PM 7/153 (1) *Mechanical inoculation of test plants* (EPPO, 2022).

Serological detection methods

DAS-ELISA has been the most commonly used method for detection of APLV and APMMV and high-titre antisera can be prepared. Although antibodies used in ELISA may be strain-specific (Koenig *et al.*, 1979) depending on the supplier, strain specificity can be overcome by using a mixture of antisera for each strain group (Schroeder & Weidemann, 1990). Other APLV antibodies may show wider specificity reacting with related tymoviruses (EPPO, 2018). Since more specific antisera might not detect all strains, it is important to address specificity of all antibodies in the validation of serological tests. Further details on DAS-ELISA can be found in EPPO Standard PM 7/125 *ELISA tests for viruses* (EPPO, 2015a).

Molecular methods

The one-step RT-PCR test described in EPPO Diagnostic Standard PM 7/132 (EPPO, 2018) using primers designed by Kreuze *et al.* (2013) can be used for detection of APLV, APMMV and other tymoviruses (e.g. EMV, *Physalis mottle virus* and *Scrophularia mottle virus* followed by sequencing of the PCR amplicon for confirmation of virus identity. Primers are also available for the differential detection of APLV and APMMV (Koenig & Ziebell, 2014) but as far as is known these tests have only been used for identification of purified virus. Additionally, two primer sets of RT-PCR and nested PCR for APLV have also been described, which are said to accurately diagnose APLV (Lee *et al*., 2015) but is not known to have been validated for the detection of APLV in potato plants.

PATHWAYS FOR MOVEMENT

Local spread of APLV/APMMV occurs via contact between infected and non-infected plants (Jones & Fribourg, 1977) or mechanical transmission from infected plants to non-infected plants by for example, passage of people and machinery through the crops. Plants for planting (including tubers) of potato and possibly maca, and ulluco moved locally or internationally constitute a major pathway for movement. Additionally, movement of plants (including TPS) from gene bank collections established before quarantine measures were introduced at import may present a major risk. The increasing interest in use of TPS for commercial potato production, means that care should be taken to ensure that parent plants used to produce the TPS are free from APLV/APMMV. Additionally, infected pollen moved for potato breeding may possibly present a risk of introducing the virus into breeding programmes, although there is currently no evidence of pollen transmission. Similarly movement of infected seed of maca (Alcazar *et al.*, 2003) may present a risk. Ware potatoes should not present a pathway since they are not meant to be planted. Interestingly, APLV has been detected in an illegal import of tubers for consumption (EUROPHYT, 2017).

Although perhaps unlikely for semi-persistent transmission, the pathway of viruliferous vectors of APMMV and probably also of APLV, *Epitrix* spp., may present a pathway for entry into a country if the flea beetles are able to retain the virus for several weeks, and escape at import to infect potato or other susceptible plant species.

PEST SIGNIFICANCE

Economic impact

In Peru no effect on yield was reported for potato plants infected with *Andean potato mottle virus*, APLV, *Potato virus S* or *Potato virus S* although significant reductions were found for *Potato leafroll virus* and *Potato virus Y* (CIP, 1987). However, since leaf distortion and chlorosis have been reported in potato (see section on Symptoms) such foliar symptoms are likely to affect the photosynthesis in the symptomatic leaves, and therefore to impact the yield and/or quality of tubers. However, the magnitude of such an impact is uncertain (EFSA, 2020) and in the experiments in Peru it was suspected that since Andean cultivars generally have long stolons, some of the tubers harvested from the root zone of infected plants may have been produced by adjacent healthy plants.

Additionally, if APLV (or APMMV) were to be introduced into a country and then established, export of potatoes to countries where these were regulated as quarantine pests would be affected resulting in economic loss.

Control

Control depends on the production of high-quality planting material from virus-free nuclear stock or true potato seed that is produced from APLV (and APMMV), free parents in a pest free area or a protected facility or a pest-free production system according to PM 3/61 *Pest-free areas and pest-free production and distribution systems for quarantine pests of potato* (EPPO, 2019b) with appropriate measures to minimize mechanical transmission. Planting should be in fields free of potential vectors and volunteer plants. Measures to minimize mechanical transmission should be used. Testing for asymptomatic infected plants and roguing of infected plants should be carried out. Similar measures may be used for maca and ulluco.

Phytosanitary risk

Climatic conditions will not impair the ability of APLV (and APMMV) to establish in the EPPO region. Potato is widely grown and is the main crop at risk, since other potential hosts such as maca and ulluco are not widely grown. However, the magnitude of potential impact in the EU is unclear (EFSA, 2020). Although several *Epitrix* species are reported in the EU, it is not known whether these species can transmit APLV and/or APMMV, since the specific *Epitrix* species transmitting APLV and APMMV is not known (EFSA, 2020).

PHYTOSANITARY MEASURES

EPPO recommends its member countries to prohibit the import of all breeding material of potato, of whatever origin, except under a special permit, subject to post?entry quarantine (EPPO, 2017; 2019a). Once tested and free from pests it may be released from quarantine and moved within the EPPO region.

Certified seed potatoes (micropropagative material and minitubers) may be traded if they meet the requirements of EPPO Standards PM 3/62 *Production of pathogen-free microplants of potato* (EPPO, 2019c) and PM 3/63 *Production of pathogen-free minitubers of potato* (EPPO, 2019d) respectively. For import of seed potatoes and ware potatoes, EPPO recommends that trade should be subject to transitional arrangements described in PM 8/1 *Co mmodity-specific phytosanitary measures for potato* (EPPO, 2017), which requires for countries where APLV and APMMV occurs, import from a pest-free area and from a pest-free potato production and distribution system, according to EPPO Standard PM 3/61 *Pest-free areas and pest-free production and distribution systems for quarantine pests of potato* (EPPO, 2019b). Additionally, for countries in Central and South America where APLV and APMMV does not occur, recommendations are confirmation by detection survey that APLV and APMMV does not occur and inspection or testing of tubers on import.

Additionally import of potato is regulated/prohibited in many EPPO countries. In the EU, the import of seed potatoes and plants (including true potato seed for planting of stolon-or tuber-forming species of *Solanum* L. or their hybrids is prohibited from third countries, other than Switzerland, by Annex VI of Commission Implementing Regulation (EU) 2019/2072 (EU 2022). Furthermore, such material stored in gene banks or genetic stock collection are subject to quarantine restrictions. Entry of ware potatoes is also regulated, and import is only permitted from specified countries, which currently does not include countries in Central and South America. However, as long as ware potatoes are not planted and only used for consumption or processing, the ability of APLV and APMMV to establish is likely to be very low (EFSA, 2020).

Historically, other than potato, EPPO countries have not prohibited the import of Andean root and tuber crops, which may be potential hosts of APLV and APMMV such as maca and ulluco. However this is changing, and a risk assessment has been carried out on ulluco from Peru (EFSA, 2021); and in the EU, Implementing Regulation (EU) 2018/2019 (EU, 2018) prohibits the introduction of plants for planting (other than seeds and *in vitro* material) of ulluco from third countries.

The pathway of viruliferous vectors of APLV hitchhiking on imported products is possibly open, based on comparisons with the biology of closely related viruses (in the same genus or family) (EFSA, 2020).

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