EPPO Datasheet: *Emaravirus rosae*

Last updated: 2024-09-06

IDENTITY

Preferred name: *Emaravirus rosae*
Taxonomic position: Viruses and viroids: Riboviria: Orthornavirae: Negarnaviricota: Polyploviricotina: Bunyaviricetes: Elliovirales: Fimoviridae
Other scientific names: *RRV, rose rosette emaravirus, rose rosette virus*
Common names: rose rosette disease
view more common names online...
EPPO Categorization: A1 list
view more categorizations online...
EU Categorization: Emergency measures (formerly), A1 Quarantine pest (Annex II A)
EPPO Code: RRV000

more photos...

Notes on taxonomy and nomenclature

The International Committee on Taxonomy of Viruses (ICTV) approved and ratified relevant changes to virus taxonomy in March 2021. The ICTV mandated a uniform rule for virus species naming, which follows the binomial 'genus-species' format with or without Latinized species epithets, and all Study Groups were requested to convert all previously established species names to the new format. The ICTV has also abolished the notion of a type species, i.e., a species chosen to serve as a name-bearing type of a virus genus (Walker *et al.*, 2021). From here, the preferred name for the disease is rose rosette disease, the virus name *Emaravirus rosae*, and the virus acronym RRV.

HOSTS

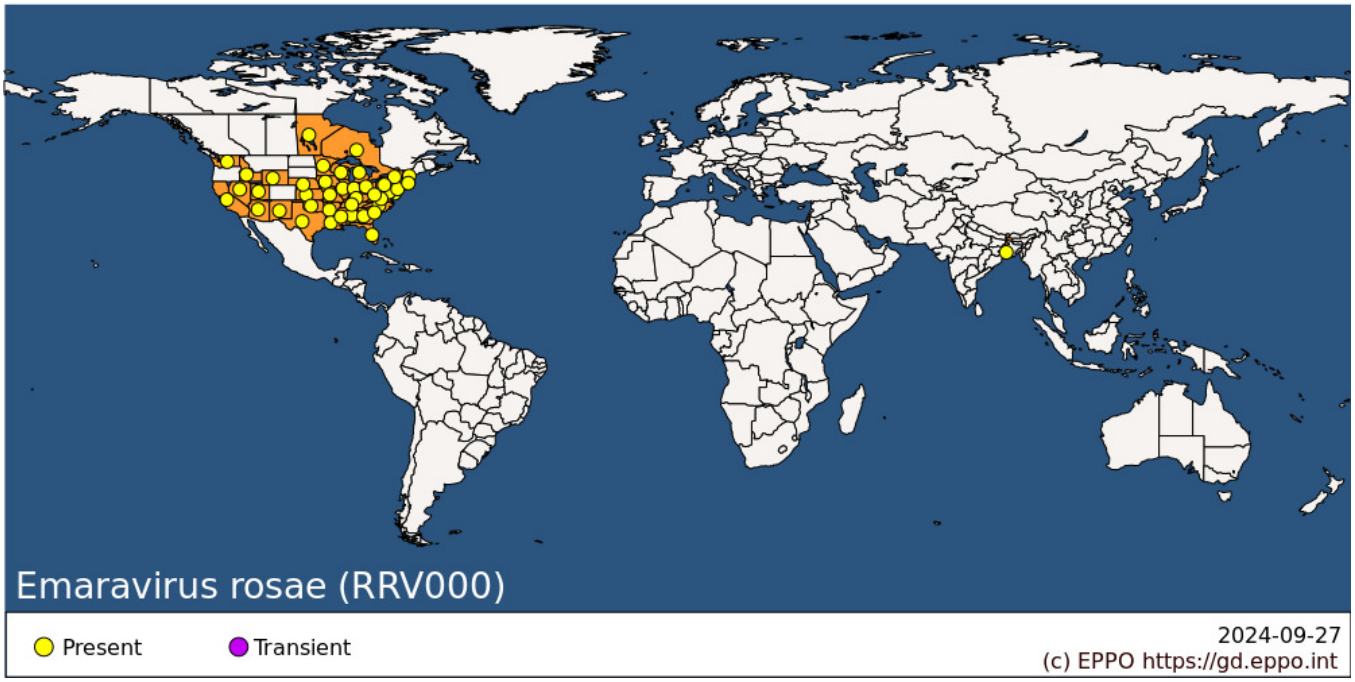
Most *Rosa* spp. and cultivated varieties such as climbers, hybrid teas, floribundas, and miniature roses are susceptible, at variable levels, to the disease (Claros *et al.*, 2022). However, at the light of ongoing genetic studies seeking resistance to rose rosette disease, it appears that wild rose species native to North America and some from Asia may be a source of resistance to the rose rosette disease. In fact, although no complete resistance to rose rosette disease has been found among the major commercial rose cultivars, high levels of resistance have been found in a few cultivars with parentage originating from North American rose species (*R. acicularis*, *R. arkansana*, *R. blanda*, *R. californica*, *R. carolina*, *R. palustris*, *R. pisocarpa*, and *R. setigera*) and Asian rose species (*R. spinosissima*, *R. wichuraiana*, and *R. bracteata*). Most of these species and species hybrids have not been significantly explored for commercial breeding (Hochhaus *et al.*, 2023; Amrine *et al.*, 2002).

Mechanical inoculation tests resulted in the detection of RRV in newly developed leaves of tomato, pepper, *Nicotiana* spp., cucumber, squash, courgette (zucchini), pumpkin, pea, peanut, soybean, spinach, okra, and *Chenopodium* spp. by RT-PCR, but no severe symptoms were detected. *Chenopodium* spp., spinach, cucumber, and *Nicotiana rustica* developed mild chlorotic or necrotic lesions with variable shapes and patterns on systemically infected leaves (Atallah *et al.*, 2022). The lack of notable, rapidly developed, characteristic symptoms hamper these hosts' use as diagnostic indicator plants.

Host list: *Rosa arkansana var. suffulta, Rosa arkansana, Rosa banksiae, Rosa bracteata, Rosa canina, Rosa dumetorum, Rosa foliolosa, Rosa fortuniana, Rosa glauca, Rosa hybrids, Rosa multiflora, Rosa nutkana, Rosa pisocarpa, Rosa roxburghii, Rosa rubiginosa, Rosa rugosa, Rosa soulieana, Rosa spinosissima, Rosa villosa, Rosa wichuraiana, Rosa woodsii, Rosa x odorata*

GEOGRAPHICAL DISTRIBUTION

RRV is reported to be epidemic in North America, in the USA and Canada (Bahari, 2015; Anon., 2024) and emerging in India (Chakraborty *et al.*, 2017). RRV is not reported elsewhere.



Asia: India (West Bengal)
North America: Canada (Manitoba, Ontario), United States of America (Alabama, Arizona, Arkansas, California, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wisconsin, Wyoming)

BIOLOGY

The biology and epidemiology of RRV are closely related to that of its eriophyid mite vectors: *Phyllocoptes fructiphilus*, the most studied species, and the recently described species, *P. arcani* sp. nov. (Druciarek *et al.*, 2023). This section focuses on the overlapping biology of RRV and *P. fructiphilus* on *Rosa* spp. During the spring-summer growing season, viruliferous *P. fructiphilus* can reach the host by wind or other mechanical means. *P. fructiphilus* can be found sheltering under bud scales and on petals (T. Druciarek, pers. comm.), growing shoot tips (Hoy, 2013), within leaf folds of new shoots, or at petiole bases (Babu *et al.*, 2015, citing others). The development from egg to adult takes approximately 11 days at 23°C (Kassar and Amrine, 1990). Multiple generations are then produced until the weather turns cold in the autumn; in mild weather, development may occur into the winter months (Tuffen, 2016, citing Amrine, 1996; Hoy, 2013). During the winter, females overwinter until early spring, hiding in protected inner plant places, such as beneath the bark or bud scales, on living host tissue (Babu *et al.*, 2015, citing others). However, under greenhouse conditions *P. fructiphilus* generations are continuously produced without overwintering (T. Druciarek, pers. comm.). Passive aerial dispersal has been suggested as the primary way that eriophyids spread (Michalska *et al.*, 2010; Sabelis and Bruin, 1996). This mode of spreading is also characteristic of *P. fructiphilus*. Although the maximum distance *P. fructiphilus* can spread by wind is unknown.

Transmission

RRV is transmitted by *P. fructiphilus* and *P. arcani*, *as described above and* by grafting (Di Bello, 2015; Di Bello *et al.*, 2017). RRV vegetative propagation was suggested by Baker *et al.* (2014) but not demonstrated, the observation by Doudrick (1984) that cuttings from infected plants are less likely to root weakens the hypothesis of RRV being spread through vegetative propagation. Mechanical transmission studies using crude extracts (Doudrick, 1984; Epstein and Hill, 1999), showed that 5 out of 123 inoculated rose plants developed symptoms when a chilled (4^{o}C) buffer containing antioxidants was used. Transmission of RRV to adjacent plants through root grafting was

hypothesized (Allington *et al.*, 1968) but not demonstrated. In addition, it is not clear whether root grafting happens in roses (Ong *et al.*, 2014). No evidence of RRV seed and soil transmission was found (Di *et al.*, 1990; Epstein and Hill, 1995; Windham *et al.*, 2016). There is no evidence to suggest that RRV is transmitted through pollen, and no specific studies or references supporting pollen transmission have been found. For the other emaraviruses described to date, no transmission by pollen has been reported (Mielke-Ehret and Mühlbach, 2012). Attempts to transmit the disease by dodder (*Cuscuta campestris, C. gronovii* and *C. pentagona*) failed due to the dodder not producing haustoria on rose (Doudrick, 1984; Epstein and Hill, 1995; Epstein and Hill, 1999).

DETECTION AND IDENTIFICATION

Symptoms

The symptoms of rose rosette disease are highly variable depending on the *rose* species, cultivar, and plant development stage. Symptoms may vary within the same cultivar, whether they are grown in the same location or in different locations (Epstein and Hill, 1995; Windham *et al.*, 2014 a,b). Rose rosette disease symptoms include rapid elongation of lateral shoots, thickening of shoots, reddening of leaves and shoots, leaves showing critical nutritional deficiencies, masses of shoot proliferation (witches' broom), excessive thorns, malformation, reduced flowering, and deformed buds and flowers (Amrine *et al.*, 1988; Epstein and Hill, 1995, Dobhal *et al.*, 2016). Infected plants become severely disfigured within one to three years after infection, and they usually die before the end of the first winter after symptoms become apparent. Otherwise, plant death occurs after two to four years. The incubation period reported in the literature varies from a few weeks to over one year (Epstein and Hill, 1999; Di Bello *et al.*, 2017; Tipping and Sindermann, 2000).

Morphology

Transmission electron microscopy has revealed double membrane-bound particles of 80–120 nm in diameter in mechanically inoculated infected tissues of cucumber, pepper, and *N. benthamiana* (Atallah *et al.*, 2022). This observation is in agreement with the morphology of Fimoviruses, which have quasi-spherical, enveloped virions with a diameter of 80–150 nm (Digiaro *et al.*, 2024).

Detection and inspection methods

RRV detection relies mainly on molecular tests. Different molecular and serological diagnostic methods have been developed, including Reverse Transcription (RT) conventional Polymerase Chain Reaction (PCR) and real-time RT-PCR, RT-Loop-mediated isothermal amplification (RT-LAMP), recombinase-polymerase amplification (RPA), primers for broad detection of emaraviruses and the eriophyid mite vector *Phyllocoptes fructiphilus*, ELISA, and high-throughput sequencing (HTS) using bioinformatic pipelines (Vazquez-Iglesias *et al.*, 2020; Claros *et al.*, 2022). RRV-infected plants can remain symptomless for long periods, so these diagnostic tests are necessary in conjunction with visual assessment of symptoms to speed up early detection (Vazquez-Iglesias *et al.*, 2020). A synthetic, multitarget, clonable, and non-infectious artificial positive control (APC) was designed *de novo* to be inserted in a circular plasmid vector that is amplified by most RRV-reported primers, probes, including primers for *P. fructiphilus* . The APC insert consists of a tandem of primers designed mainly to amplify control sequences for RRV, which also amplify a control product for broad detection of emaraviruses and *Phyllocoptes fructiphilus* using various nucleic acid amplification methods, including RT-PCR, RT-real-time PCR, RT-LAMP, and RPA (Ruschel *et al*., 2023). The APC-RRV system is robust, not-infectious, and capable of being integrated into 1.2 mm paper matrices. The APC is cloneable and subjected to stringent quality control, making it suitable for quarantine surveillance and routine diagnostics of RRV. This approach reduces the need to handle and transport infected tissue samples (Ochoa-Corona, personal communication).

PATHWAYS FOR MOVEMENT

RRV and its mite vectors are considered to be potentially associated with all *Rosa* species and cultivars. The main pathway for RRV and its mite vectors is the international movement of infected *Rosa* plants for planting (e.g. bare-rooted plants, potted plants, cuttings, rootstocks, and possibly tissue cultures). Pollen and seed are not considered as a potential pathways, as there are no reports of RRV detection in these plant parts. Rose cut flowers could also

transport RRV and its vectors, however the possibility of finding flowers with rose rosette disease symptoms in the market is low because they will be discarded due to the high-quality selection standards of cut roses (EPPO, 2018, Vazquez-Iglesias *et al*., 2020; Claros *et al*., 2022; Hochhaus *et al*., 2023).

PEST SIGNIFICANCE

Economic impact

RRV and its vector, the eriophyid mite *P. fructiphilus*, have had high economic and social impacts in the USA. All species and cultivars of *Rosa* are considered at risk from the virus and vector, as no known tolerant or resistant species or varieties have been released at present. In the USA, RRV constitutes a severe threat to the rose industry, which includes commercial nursery production, breeding, private gardens, landscaping services, and retailers. The severity of the rose rosette disease impact and broad distribution seen in the continental USA has been described as 'an epidemic' (Bahari, 2015) and subsequently as 'endemic' (Pemberton *et al.*, 2018), which led the United States Department of Agriculture (USDA) to fund research to devise solutions to control the disease and prevent more damage.

Control

Once RRV infects plants, no curative treatment is available, so it is recommended that infected plants are removed before reaching an advanced final stage due to their unsightly appearance (Pemberton *et al.*, 2018). Removal and destruction must include root systems, as RRV infection is systemic (Di Bello *et al.*, 2017). This practice should also help reduce the mite population.

When removing plants, precautions should be taken to avoid the spread of *P. fructiphilus* and RRV, e.g. bagging removed plant material during transportation, not leaving removed plant material on the site (Windham *et al.*, 2016). Removal of symptomatic plants is however not considered fully effective as asymptomatic plants may also be present (EPPO, 2018).

Not all authors agreed on the efficacy of measures aimed at controlling the mite, especially the use of acaricides. Mites tend to shelter in crevices which are difficult for products to reach (Cloyd, 2013, Hand, 2014). In addition, treatments will not entirely prevent transmission of the virus to healthy roses as the vector has a short inoculation access period (1h) (EPPO, 2018).

The efficacy of foliar applications of acibenzolar-S-methyl (ASM), a plant systemic acquired resistance inducer, in reducing rose rosette disease severity was studied at 50-100-mg/L of ASM concentrations in glasshouse conditions on *Rosa* species cv. Radtkopink ('Pink Double Knock Out'). ASM delayed the incidence of rose rosette disease compared to nontreated controls after three trials. Overall, plants treated with ASM at the 50-mg/L concentration had 36 to 43% reduced disease incidence compared with the water control. Real-time RT-PCR assessed the RRV presence. Treatment of two cultivars of rose, 'Radtkopink' and 'Meijocos' ('Pink Drift'), with weekly foliar applications of ASM showed no adverse effect on flowering and plant growth (Babu *et al.*, 2022).

In the USA and Canada, IPM strategies are being developed to contain the disease and usually include:

- Use of healthy planting material.
- Avoiding dense plantations.
- Use of other plants as barriers within rose gardens (to limit wind dispersal of infectious mites).
- Disinfection of pruning tools.
- Systematic destruction of diseased plants and disposal of potentially infested plant material.
- Chemical treatments might help reduce mite populations and limit disease spread, but very limited experimental results can be found in the literature, and the risk associated with developing resistance to acaricides cannot be ignored.

Genetic studies are under way to identify resistance genes in rose populations. Quantitative trait loci (QTL) for

reduced susceptibility to rose rosette disease have been localized in tetraploid and diploid rose populations for marker-based selection to track and use a given QTL in plant breeding against rose rosette disease (Hochhaus *et al.*, 2023).

Phytosanitary risk

Roses are widely planted in the EPPO region, especially in gardens, landscaped areas, tourist sites, and are also a valued nursery product. If RRV was introduced into the EPPO region, the highest economic impacts could be expected in nurseries and areas producing rose products, such as rose oil and pharmaceuticals. Potential environmental impacts are expected if native (especially endangered) *Rosa* species are infected in regions populated with susceptible hosts. Social impacts would occur through the loss of employment and income in the production and processing industry (especially for rose flowers for oil) and in those countries where *Rosa* has significant cultural importance.

The risk of entry on *Rosa* plants for planting (except seeds and pollen) is considered high with moderate uncertainty. The likelihood of establishment in regions where roses grow well is high because of the high volume of international trade and movement of people. If RRV and vector are introduced into the EPPO region the spread would be moderate to high due to the extensive trade in *Rosa* and the aerial dispersal of *P. fructiphilus*, with moderate uncertainty (EPPO, 2018).

PHYTOSANITARY MEASURES

Considering the severe damage caused by RRV to roses, avoiding its introduction into the EPPO region is desirable. Effective phytosanitary measures should include monitoring and early detection of infections, destruction of RRV-infected plant material, and control of mite populations. Quarantine regulations and restrictions on the movement of rose plants from areas where rose rosette and mite vectors were reported are essential. It can be recommended that rose plants for planting and cut flowers should originate from pest-free areas for RRV, *P. fructiphilus*, and *P. arcani* and have been packed in conditions preventing mite infestation during transport (EPPO, 2018).

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Datasheet history

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