EPPO Datasheet: *Daktulosphaira vitifoliae*

Last updated: 2023-12-01

IDENTITY

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Preferred name: *Daktulosphaira vitifoliae*
Authority: Fitch
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Hemiptera: Sternorrhyncha: Phylloxeridae
Other scientific names: *Dactylosphaera vastatrix* (Planchon), *Dactylosphaera vitifoliae* (Fitch), *Pemphigus vitifoliae* Fitch, *Peritymbia vastatrix* (Planchon), *Phylloxera pemphigoides* Donnadieu, *Phylloxera vastatrix* Planchon, *Phylloxera vitifoliae* (Fitch), *Rhizaphis vastatrix* (Planchon), *Viteus vitifoliae* (Fitch)
Common names: grapevine leaf louse, grapevine louse, grapevine phylloxera, vine louse
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EPPO Categorization: A2 list
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EU Categorization: PZ Quarantine pest ((EU) 2019/2072 Annex III), RNQP ((EU) 2019/2072 Annex IV)
EPPO Code: VITEVI

Notes on taxonomy and nomenclature

Grapevine phylloxera, *Daktulosphaira vitifoliae*, is recognized as a single species (Granett *et al*., 2001), although variability in reproductive biology and feeding behaviour has been observed between the currently recognized "biotypes" (Forneck *et al*., 2016).

HOSTS

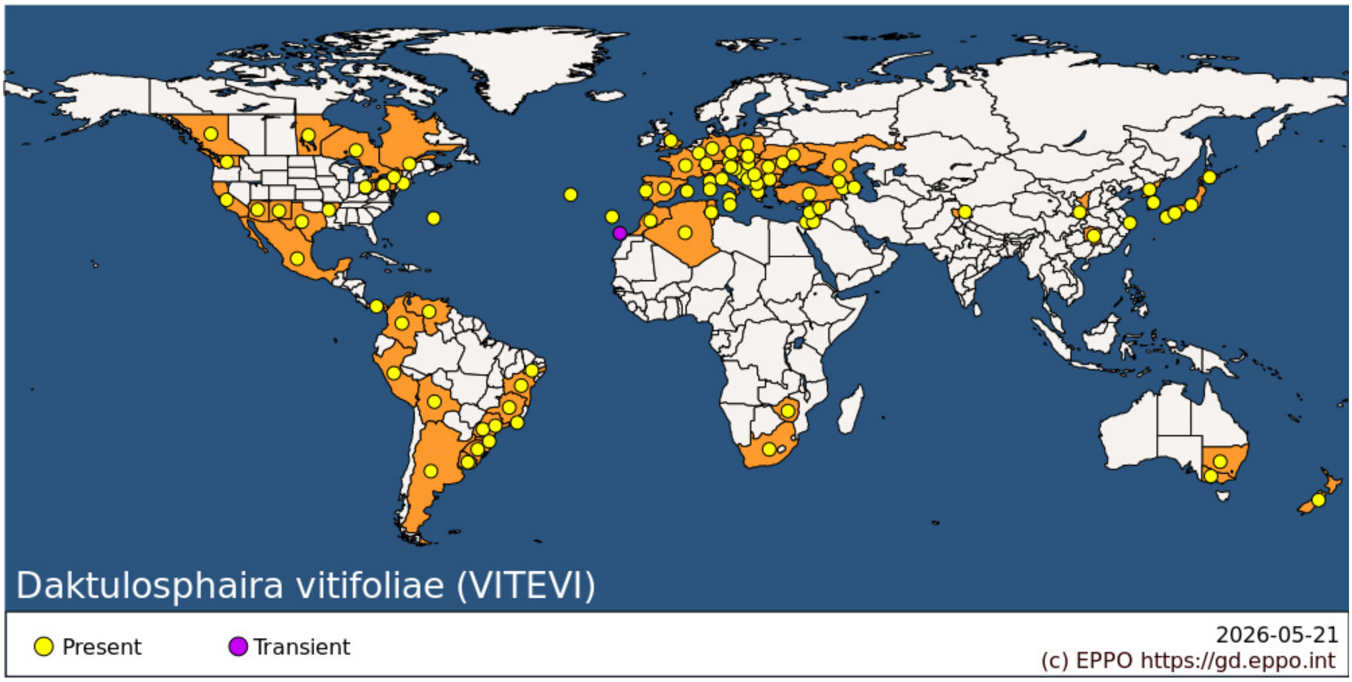
The principal economic host is *Vitis vinifera* subsp. *sativa* (grafted or ungrafted) which is used for wine, table grape and raisin production. Additional hosts include interspecific hybrids for grapevine production (grafted) and abandoned rootstocks (American *Vitis* hybrids that form leaves). American *Vitis* species are described in Walker *et al*., 2019).

It should be noted that there are large differences in tolerance or resistance between *Vitis* species: *V. vinifera* is extremely susceptible to attack by the *root-feeding* form (see Biology) but the leaves have usually been found to be resistant, whereas the American (with a few exceptions) and some Asian species of *Vitis* tolerate extensive galling of the leaves and are tolerant of root attack (e.g. Downie *et al*., 2000; Lawo *et al*., 2013; Lund *et al*., 2017). For this reason, the American species *V. riparia* is widely used in interspecific hybrid rootstock production. Other American species are partially resistant (*V. rupestris*, *V. berlandieri*) or susceptible (*V. labrusca*) to root-borne damage. *V. vinifera* is now widely grown throughout the EPPO region but is generally grafted onto rootstocks which are resistant to root-feeding *D. vitifoliae*. Some observations have shown that *V. vinifera* vines or interspecific hybrids thereof, in particular in recent years, are infested by leaf-feeding (gallicole) grapevine phylloxera (Jubb *et al*., 1976; Stevenson & Jubb, 1976; Vidart *et al*., 2013; Fahrentrapp *et al*., 2015; Forneck *et al*., 2019) in commercial vineyards which seems contrary to the feeding behaviour on this host mentioned earlier. The underlying causes in the change in this behaviour may be environmental, vineyard management (decreased pesticide application) and grapevine phylloxera biotypes (Powell *et al*., 2013; Wilmink *et al*., 2021a) and are not yet clear.

Host list: *Vitis aestivalis*, *Vitis amurensis*, *Vitis arizonica*, *Vitis berlandieri*, *Vitis californica*, *Vitis candicans*, *Vitis cinerea*, *Vitis coignetiae*, *Vitis davidii*, *Vitis flexuosa*, *Vitis girdiana*, *Vitis heyneana*, *Vitis hybrids*, *Vitis labrusca*, *Vitis riparia*, *Vitis rupestris*, *Vitis vinifera subsp. sylvestris*, *Vitis vinifera*, *Vitis vulpina*, *Vitis x champinii*

GEOGRAPHICAL DISTRIBUTION

D. vitifoliae is native to North America and was introduced into Europe in the second half of the 19th century. It has continued to spread throughout the 20th century and is now found in all wine growing areas worldwide. Grapevine phylloxera occurs in cultivated vineyards, often feeding on roots (of rootstocks) and infections may be latent (in particular with the use of resistant hosts).



EPPO Region: Algeria, Armenia, Austria, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, France (mainland, Corse), Georgia, Germany, Greece (mainland), Hungary, Israel, Italy (mainland, Sardegna, Sicilia), Jordan, Luxembourg, Malta, Moldova, Republic of, Montenegro, Morocco, North Macedonia, Poland, Portugal (mainland, Azores, Madeira), Romania, Russian Federation (Southern Russia), Serbia, Slovakia, Slovenia, Spain (mainland, Islas Baleares, Islas Canárias), Switzerland, Tunisia, Türkiye, Ukraine, United Kingdom (England)
Africa: Algeria, Morocco, South Africa, Tunisia, Zimbabwe
Asia: China (Hunan, Shaanxi, Shanghai), India (Jammu & Kashmir), Israel, Japan (Hokkaido, Honshu, Kyushu, Shikoku), Jordan, Korea, Democratic People's Republic of, Korea, Republic of, Lebanon, Syrian Arab Republic
North America: Canada (British Columbia, Manitoba, Ontario, Québec), Mexico, United States of America (Arizona, Arkansas, California, Connecticut, New Mexico, New York, Ohio, Pennsylvania, Texas, Washington)
Central America and Caribbean: Bermuda, Panama
South America: Argentina, Bolivia, Brazil (Bahia, Minas Gerais, Parana, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, Sao Paulo), Colombia, Peru, Uruguay, Venezuela
Oceania: Australia (New South Wales, Victoria), New Zealand

BIOLOGY

Grapevine phylloxera has a complex lifecycle with several variants (reviewed in Forneck & Huber, 2009; see also life cycle provided at https://gd.eppo.int/taxon/VITEVI/photos - Forneck & Bauer, 2020). On American *Vitis* species, *D. vitifoliae* lives on the roots and leaves and has a full reproductive cycle (holocycle) of development with the presence of parthenogenetic and sexual forms of the phylloxerid. This full cycle involves migration from the roots to the leaves and back to the roots, as well as an alternation of parthenogenetic and sexual reproduction. On grafted and own-rooted cultivars of the European grapevine, *V. vinifera*, the phylloxerid normally infests only the root parts of the plant and undergoes an incomplete (parthenogenic) cycle of seasonal development.

D. vitifoliae hibernates as 1st and 2nd instar nymphs (hibernales) on the root system, either in galled or on non-galled root tissues (Davidson & Nougaret, 1921) and on the lignified trunk below soil. The so-called hibernating morphs survive the winter without feeding. The limiting conditions, mainly temperatures, are not well understood. In spring they regain activity, molt and continue the asexual cycle on the roots (radicole) and leaves (gallicole) of the vines (anholocycle). They continue to multiply parthenogenetically through the summer until autumn. Sexuparous forms appear and migrate (see Pathways for movement), however it is not clear if the sexual cycle is completed in commercial vineyards.

D. vitifoliae may also overwinter as a dormant winter egg produced by sexual recombination (holocycle) which is highly resistant to low winter temperatures on the trunk (below the bark) of the above soil parts of the vine. During the growing season the holocycle is induced in root-feeding larvae. Winged morphs leave the ground and lay eggs on above soil plant parts of the vine. The eggs hatch and produce sexual male and female morphs that mate and the females lay one egg (winter egg) (Rübsaamen & Ritter, 1900). In this full reproductive cycle, winter eggs on the stems hatch in spring, after the foliage has come out, and the yellow phylloxerids developing from these eggs, the *gallicolae* form, migrate to the leaves, where they begin feeding, thus causing the formation of galls. As soon as the phylloxerids mature, they lay numerous, up to 400-600 eggs inside each gall. There are four to six generations of the *gallicolae* during the growing season. Individuals of the generations of these leaf-feeding phylloxerids migrate to the ground and burrow beneath the soil to the fine roots, where they can live for a number of parthenogenetic generations, before a new holocycle may be initiated.

Even very severe winter conditions do not kill the winter eggs. *D. vitifoliae* can theoretically survive under all climatic conditions tolerated by its host plant. Few studies are available on the temperature window of hibernation of root-feeding grapevine phylloxera, which was reported to occur below 19°C (Davidson & Nougaret, 1921), whereas Zhang *et al*. (2010) found hibernales becoming active as soil temperatures exceeded 17°C.

For more information on the temperature affecting the root-feeding grapevine phylloxera population growth see Maillet, 1957; Rilling, 1964; Daris, 1970; Bovey, 1972; Gorkavenko, 1975; Gorkavenko & Gorkavenko, 1977; Granett & Timper, 1987; Skinkis *et al*., 2009; Benheim *et al*., 2012; Powell, 2012; Powell *et al*., 2013).

Most of the published and anecdotal information related to the grapevine phylloxera distribution in soil focuses on textural properties, particularly on the ratio of sand to clay content. Historically, sandy soils were reported to decrease root-feeding grapevine phylloxera (for a review: see Devitz, 1919) and may permit the use of own-rooted viticulture, as long as extended flooding periods are used to irrigate the vines (Torregrosa *et al*., 1997). As shown by Reisenzein *et al*. (2007), further and combined effects of soil pH, organic carbon and soil texture also affect abundance of grapevine phylloxera populations.

DETECTION AND IDENTIFICATION

Symptoms

On the shoot/leaves: *D. vitifoliae* feeding on the upper side of young (meristematic) leaves induce a leaf gall on the lower side (Powell *et al*., 2013). The pocket-like galls are the size of peas and remain open at the adaxial side. Although leaf galling by grapevine phylloxera does not always cause significant losses in grape production, severe infestations do cause considerable distortion and leaf drop of affected leaves in subsequent years.

On the root system/fine roots: Root infestation symptoms include tuberosities, crater-like swellings on mature lignified roots and nodosities, hook-like swelling that are formed on the root tip of young and fibrous roots. Mainly, tuberosities lead to a further decay by destructive soil borne pathogens, lead to a decrease of vigour and eventual death of the vines within 3-10 years (Granett *et al*., 2001, Powell *et al*., 2013). Nodosities on the root tips normally do not cause severe damage to the vines and are observed on most American rootstock hybrids that are being used in commercial viticulture.

Morphology

Adult: Globular phylloxerid, 1.6-1.8 mm long and 1-1.2 mm wide; cephalothorax widened and its dorsal face rounded off; abdomen tapers off and is slightly splayed posteriorly; antennae composed of three segments, the 3rd one being the most developed and provided with a large primary latero-external sensorium; the processus terminalis is short and broad, little differentiated at its base, having a length which is one-third in excess of that of the 3rd segment (dimension taken from the base of the sensorium to the tip of the antenna, excluding the apiales); dorsal cuticle is rough, but entirely free from tubercles. The rostrum reaches the femora of the foremost legs. The root-feeding adult is smaller, being about 1 mm in length. It is distinguished by the presence of tubercles on the dorsal surface, 12 on the head, 28 on the thorax and 30 on the abdomen. On the antenna, the processus terminalis is well differentiated and much finer than that of the leaf-feeding form (e.g. Kingston *et al*., 2007).

Eggs: The eggs are 300-330 x 160-170 µm, have an oval form and range from bright yellow to dark yellow or brown.

***Larvae*:** The four larval stages have the same general external morphology as the adult. In the later stages, the width of the body increases more rapidly than the length, and the body thus becomes rounder in outline. Similarly, the size of the legs and antennae does not increase at the same rate as that of the body; they therefore appear smaller in the later stages. From the second stage onwards, the tubercles on the dorsal surface become more obvious. Larval stages (winged forms are described and reviewed in detail in Forneck & Huber, 2009).

Detection and inspection methods

Symptoms on the leaves and roots are used as indicators for the presence of *D. vitifoliae* on the vine.

Predominant conventional methods to detect *D. vitifoliae* are conducting a ground survey (visual inspection of the root system), looking for the insects and associated root symptoms (nodosities, tuberosities) employing a shovel and hand lens. More sensitive approaches are being used in order to detect grapevine phylloxera DNA in soil samples (Herbert *et al*., 2008; Giblot-Ducray *et al*., 2016) or trapping techniques to monitor dispersal stages of *D. vitifoliae*. These traps (pitfall, sticky, or emergence) are easy to use, simply constructed and allow the quantification of migrating grapevine phylloxera in the field (Powell *et al*., 2007). Indirect techniques, such as monitoring stress symptoms (decreased vigour) are being tested but yet not confirmed and still in development (e.g. Blanchfield *et al*., 2006). Sticky traps for wind-blown dispersal should be located 1.3 – 1.5m above ground). Insect samples may be quickly identified with lab- or field compatible LAMP diagnostic assays (Agarwal *et al*., 2020). Phytosanitary procedures for inspection of places of production of *Vitis* plants for planting are provided in EPPO Standard PM 3/85 (EPPO, 2018).

PATHWAYS FOR MOVEMENT

D. vitifoliae movement by natural means is limited by life-stage and feeding site of the insect. If it remains mostly confined to the root system in the *radicicolae* form (as it does in commercial Vineyards), natural spread is limited. In areas where both root-feeding and leaf-feeding occurs (Rilling, 1964; Wilmink *et al*., 2021b), the first instars (crawlers) may migrate from root to leaves, and vice versa. Winged forms may actively migrate over longer distances in (or between) vineyards up to 100m per year. Crawlers may passively spread by being wind-blown from the foliage (EFSA PLH Panel, 2014).

D. vitifoliae movement occurs within vineyards by human assistance. Crawlers (both root- and leaf-feeding) may be spread through equipment and machinery among fields and regions. The movement occurs via soil, leaf material and (rarely) in harvested fruits. Human mediated spread via planting material pathways may occur on rooted grapevines (as hibernating crawlers on roots/winter egg on bark), dormant cane (without roots) or potted vines (with roots and leaves).

PEST SIGNIFICANCE

Economic impact

Within 25 years of the introduction of *D. vitifoliae* into France from America (about 1860) it had destroyed nearly one-third of the vineyards in the country – more than 100 000 ha – with incalculable economic and social consequences, caused by the fact that European grapevine cultivars then grown were highly susceptible. These were subsequently replaced with European cultivars (*V. vinifera* subsp. *Sativa*) grafted on American rootstocks, a practice which is now almost universal wherever *D. vitifoliae* occurs. The pest remains especially threatening for the few regions where susceptible grape cultivars are still cultivated on their own roots (rather than on resistant rootstocks). The pest is also more damaging in vineyards, soon after replantation, and damage is less significant on vigorous vines over 10 years old. Leaf infestation is reported to recently be increasing in *V. vinifera* cultivars and interspecific hybrids thereof (e.g. Granett *et al*., 2001; Vidart *et al*., 2013; Bao *et al*., 2015; Fahrentrapp *et al*., 2015; Molnar *et al*., 2009; Forneck *et al*. 2019; Wilmink *et al*., 2021a; 2021b), and environmental factors (climate change), the decreased pesticide usage and the development of grapevine phylloxera biotypes may play a role. Few studies on the economic (short and long-term) effects of the pest, when feeding on leaves and producing leaf galls, on yield and wine quality, exist. The experimental set up (insecticide treatment of infested vines or artificial infestation of non-infested vines) as well as the severity and time period seem to have an influence on the outcomes of these studies. Contradictory results were found: positive effects were shown in treated vines (against leaf-feeding grapevine phylloxera) by Schvester (1959), whereas Stevenson (1970a) found no significant effects in the same experimental set up. No negative effects in fruit quality measures in leaf-galled vines were found by Strapazzon *et al*. (1986), Strapazzon & Girolami (1985b) and Wilmink *et al*. (2022). However, McLeoad (1990) found negative effects caused by *D. vitifoliae* when vines were artificially infested before bloom.

Control

Use of resistant rootstocks has been the main and most successful long-term control measure to date. However, recent studies indicate that this practice might become less effective in future as new biotypes of *D. vitifoliae* develop (King & Rilling, 1958; Granett *et al*., 1985; Williams & Shambaugh, 1988; Forneck *et al*. 2016; Clark *et al*. 2023) that are feeding aggressively on rootstocks (e.g. AXR'1, Teleki 5C). Other management options should be considered in the short term to suppress grapevine phylloxera (leaf- and/or root-feeding) populations, as well as the use of grapevine phylloxera free plant material treated with phytosanitary treatments (e.g. hot water treatments, fumigation; see EPPO Standards PM 10/16 (EPPO, 2009) and PM 10/20 (EPPO, 2012)). Schemes for certification of grapevine planting material (EPPO Standard PM 4/8; EPPO, 2008) should provide a simple means of ensuring that all traded grapevine planting material is free from *D. vitifoliae*. Effective chemical controls against both leaf- and root-feeding morphs in the field are not available (due to world-wide regulations); for a review, see Benheim *et al*. (2012).

Phytosanitary risk

The number of important viticultural regions which remain free from grapevine phylloxera is now very limited. Within the EPPO region, these include for example Cyprus. A few vineyards in the United Kingdom (where many grapevines have been planted in the 1980s) are subject to statutory eradication procedures following pest infestations. In the context of climate change, new wine growing areas will be established in which *D. vitifoliae* introductions should be avoided in order to try to prevent new grapevine phylloxera biotypes from forming.

Once established, the insect is extremely difficult and costly to eradicate. Due to the asymptomatic spread of grapevine phylloxera on tolerant rootstocks and the fact that grapevine phylloxera cannot be currently eradicated from vineyards or from *Vitis* in neighbouring landscapes, the population size generally is increasing. Furthermore, in the traditional grape-growing areas leaf feeding grapevine phylloxera populations are now occurring (see above) and dramatically increase both the population pressure and degree of migrations within and among vineyards. Thirdly, the increased usage of fungus resistant grapevine cultivars (interspecific hybrids) that are adapted first to climate change conditions will ultimately increase the grapevine phylloxera leaf feeding populations since they are more susceptible to grapevine phylloxera leaf feeding as well (see the examples of *Vitis* hybrids bred for cold hardiness referred to in the comments of the Host plants section of EPPO GD).

Another risk is the introduction or appearance of possible new biotypes of the pest, presenting a threat to grape-growing countries within EPPO. The establishment of new biotypes which have overcome the resistance of certain rootstock cultivars could lead to a dramatic change in the phytosanitary situation in European/Mediterranean vineyards.

PHYTOSANITARY MEASURES

D. vitifoliae has been one of the classic objects of phytosanitary regulations, leading to the first international measures and agreements for phytosanitary purposes in Europe. However, it is now widespread in the EPPO region and treated by several countries (e.g. in the European Union) as a regulated non-quarantine pest (RNQP). In European Union member states, resistant rootstocks are being used and planting own-rooted susceptible vines is generally not allowed.

Grapevine-growing countries may require that plants for planting have been produced in pest free areas or treated either by fumigation, hot water or other appropriate treatment. It may be required that fruits of *Vitis* are free from leaves. As recommended during the EU Quality pest Project, when regulated as a RNQP, additional measures could include the use of resistant rootstocks, and possibly the production in pest free place/site of production under protected conditions for higher categories of plant reproductive material for the vine sector (Picard *et al*., 2018). Effectiveness of the different options in managing the risk is discussed in EFSA PLH Panel (2014).

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ACKNOWLEDGEMENTS

This datasheet was extensively revised in 2023 by Astrid Forneck (University of Natural Resources and Life Sciences, Vienna). Her valuable contribution is gratefully acknowledged.

How to cite this datasheet?

EPPO (2026) *Daktulosphaira vitifoliae*. EPPO datasheets on pests recommended for regulation. Available online. https://gd.eppo.int

Datasheet history

This datasheet was first published in the EPPO Bulletin in 1981 and revised in the two editions of 'Quarantine Pests for Europe' in 1992 and 1997, as well as in 202X. It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', 'Hosts', and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

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Co-funded by the
European Union