

EPPO Datasheet: *Gymnosporangium asiaticum*

Last updated: 2022-09-14

IDENTITY

Preferred name: *Gymnosporangium asiaticum*

Authority: G. Yamada

Taxonomic position: Fungi: Basidiomycota: Pucciniomycotina: Pucciniomycetes: Pucciniales: Gymnosporangiaceae

Other scientific names: *Gymnosporangium chinense* Long, *Gymnosporangium haraeaeum* Sydow & P. Sydow, *Gymnosporangium koreense* (Hennings) H.S. Jackson, *Gymnosporangium photiniae* (Hennings) F. Kern, *Gymnosporangium spiniferum* Sydow & P. Sydow, *Gymnosporangium unicorne* H.Y. Yun, *Roestelia koreaensis* Hennings, *Roestelia photiniae* Hennings

Common names: leaf rust of Japanese pear, leaf rust of juniper, rust of oriental pear

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EPPO Categorization: A2 list

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EPPO Code: GYMNAS



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Notes on taxonomy and nomenclature

The genus *Gymnosporangium* was established to accommodate *G. fuscum* on *Juniperus sabina*. To date, over 70 species of this genus have been reported worldwide (Zhao *et al.*, 2020). This genus has long been classified in the family *Pucciniaceae* due to its pedicellate teliospores and Group V spermogonia (Hiratsuka & Hiratsuka, 1980; Hiratsuka *et al.*, 1992; Cummins & Hiratsuka, 2003). However, recent phylogenetic studies suggested its phylogenetic distinction from core *Pucciniaceae* (*Puccinia/Uromyces*) (Maier *et al.*, 2003; Aime *et al.*, 2006). Thus, a new family, *Gymnosporangiaceae*, was proposed to accommodate the genus *Gymnosporangium* (Zhao *et al.*, 2020), and such taxonomic treatment was widely accepted thereafter (Aime & McTarggart, 2021).

Among these *Gymnosporangium* species, *G. asiaticum* was reported as a causal agent of Japanese pear rust diseases. Historically, this species was first described by Sydow (1899) as *Gymnosporangium japonicum* at Komaba, Tokyo. Miyabe (1903) considered that the Japanese pear rust fungus was a new species called *G. asiaticum*, differing from *G. japonicum*, and that its aecia also occurred on *Cydonia vulgaris* and *Chaenomeles speciosa*, and its telia on leaves of *Juniperus chinensis*. However, he did not publish a description of this species in any form. Later Yamada (1904) validly described this species based on collections by K. Hara at Kawaue-mura, Gifu prefecture of Japan. Despite the existence of the valid name *G. asiaticum*, Sydow and Sydow (1912) renamed the leaf-inhabiting form observed on juniper leaves as *G. haraeaeum*, based on the collection of Hara from Mino, Gifu prefecture, Japan. However, Hara confirmed that the alternate host (aecial host) of this rust fungus was pear (*Pyrus* spp.), while Ito further added *Photinia villosa* as an aecial host. Previously the rust fungus on *Photinia villosa* in Japan was first described under the name of *Roestelia photiniae*, and Kern (1911) classified it into the genus *Gymnosporangium* based on aecial similarities. Although *G. photiniae* was proposed, this species showed high morphological similarities with *G. asiaticum* and *G. haraeaeum*. Thus, Ito (1950) treated *G. haraeaeum* and *G. photiniae* as synonyms of *G. asiaticum* due to nomenclature priority. Moreover, Long (1914) described a new species, *Gymnosporangium chinense* based upon plant material imported from Japan in a nursery in Connecticut (US). The aecial state of this fungus was first described by Hennings (1899) based upon a specimen collected by O. Warburg on *Pyrus* sp. in Korea (Yun *et al.*, 2019). In the next year, Dietel (1900b) identified the aecial state of this fungus on *Pyrus serotina*, *Cydonia vulgaris* and *Photinia laevis* var. *villosa* which were collected by S. Kusano in Tokyo, and called it *Gymnosporangium confusum*. In 1912, Sydow and Sydow regarded the aecial state of this fungus on leaves of *Cydonia vulgaris* as a new species giving it the name *Gymnosporangium spiniferum*, based upon a specimen which was collected by Sakurai (Hiratsuka *et al.*, 1992). Yun *et al.* (2009) also reported a new species, *G. unicorne*, based on the morphological characteristics of its telia. Hitherto, these seven *Gymnosporangium* species, *G. chinense*, *G. haraeaeum*, *G. japonicum*

, *G. koreense*, *G. photinae*, *G. spiniferum* and *G. unicorne* were frequently regarded as synonyms of *G. asiaticum* (Kern 1973, Hiratsuka *et al.*, 1992). As a result of systematic studies of type materials, all of these species, with the exception of *G. japonicum*, were confirmed to be conspecific with *G. asiaticum* (Yun *et al.*, 2009). In 2020, Zhao *et al.* (2020) designated a lectotype specimen of *G. asiaticum* according to Yamada (1904), and an epitype specimen was also selected. Both morphological and molecular data were obtained from those type materials. Phylogenetic studies confirmed the species delimitation of *G. asiaticum*, and their results agreed with the taxonomic treatment of Yun *et al.* (2009), who treated *G. chinense*, *G. haraeaeum*, *G. koreense* and *G. spiniferum* as synonyms of *G. asiaticum*. Moreover, *G. unicorne*, which had been proposed as a new species by Yun *et al.* (2009), was also confirmed to be conspecific to *G. asiaticum* through molecular phylogenetic studies (Zhao *et al.*, 2020). In addition, *G. taianum* on *Cupressus duclouxiana*, which has aecial hosts on *Chaenomeles*, *Crataegus*, *Photina* and telial hosts on *Juniperus* species and their varieties, was found to be conspecific to *G. asiaticum*. The phylogenetic relationships of *G. asiaticum* with other *Gymnosporangium* species have already been studied, and *G. asiaticum* was shown to be phylogenetically close to *G. kanas*, *G. niitakayamense* and *G. hunglongense* (Zhao *et al.*, 2020).

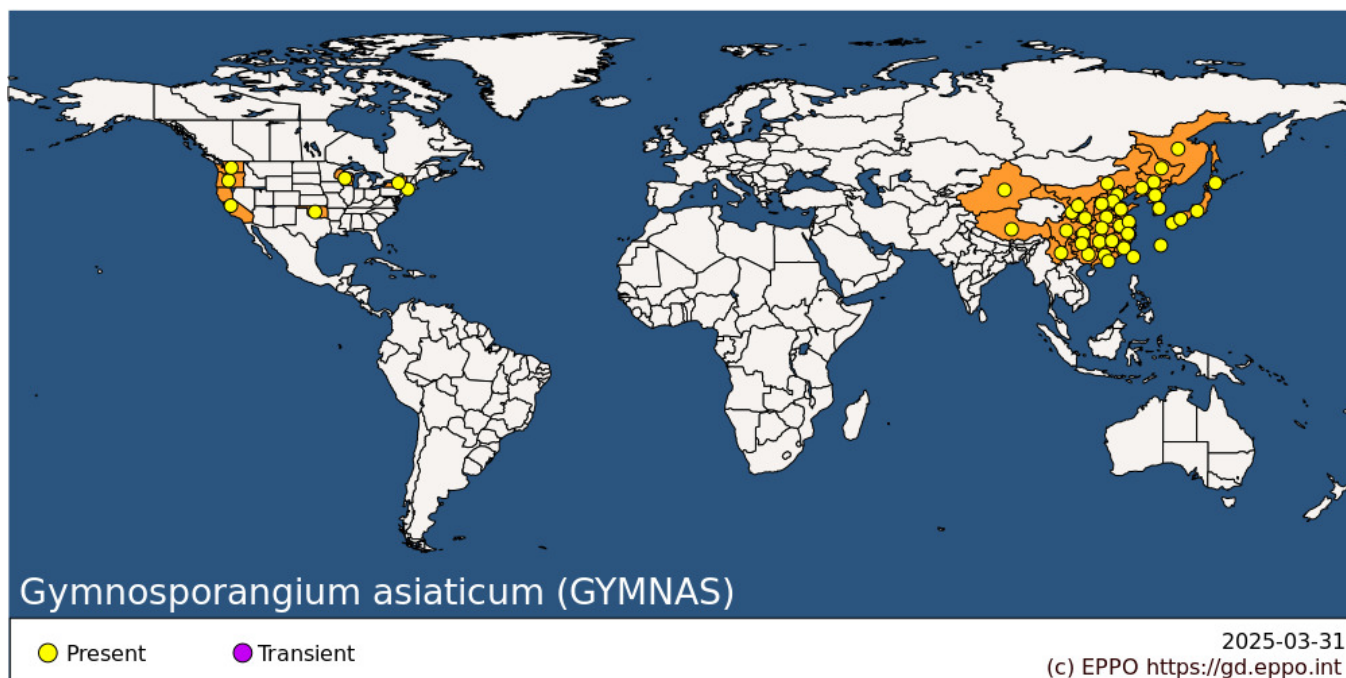
HOSTS

The most important aecial host of *G. asiaticum* is Japanese pear (*Pyrus pyrifolia*), and possibly other Asian pear species. European pear (*P. communis*) and quince (*Cydonia oblonga*) are recorded as hosts, but there is little information to suggest that they are significant hosts. Tai (1933) noted that, in China, most foreign pear cultivars were immune; a few were slightly susceptible, but much less than Japanese pear (the cultivars concerned are not currently grown in Europe). In Japan, neither of the two races of the fungus described by Sakuma (1992) gave more than tiny, limited lesions on *P. communis*. Other hosts, in the subfamily *Pomoideae* of the family *Rosaceae*, are *Chaenomeles*, *Crataegus* and *Photinia*. The telial hosts in Asia are *Juniperus chinensis* and the closely related *J. procumbens*, which are not native to Europe. The former is widely grown as an ornamental tree or as a bonsai plant. In western North America, the alternate host is the introduced species, *J. chinensis* (Ziller, 1974). Through literature review and comprehensive taxonomic studies, the host range and their geographic distributions were revised and illustrated in Zhao *et al.* (2020).

Host list: *Chaenomeles cathayensis*, *Chaenomeles japonica*, *Chaenomeles lagenaria*, *Chaenomeles x superba*, *Crataegus cuneata*, *Crataegus pinnatifida*, *Crataegus wilsonii*, *Cupressus duclouxiana*, *Cydonia oblonga*, *Juniperus chinensis* var. *sargentii*, *Juniperus chinensis*, *Juniperus excelsa*, *Juniperus procumbens*, *Juniperus sabina*, *Juniperus scopulorum*, *Juniperus squamata*, *Juniperus tibetica*, *Juniperus virginiana*, *Malus asiatica*, *Malus domestica*, *Malus ioensis*, *Malus prunifolia*, *Malus spectabilis*, *Malus toringo*, *Pourthiaea villosa*, *Pseudocydonia sinensis*, *Pyrus betulifolia*, *Pyrus bretschneideri*, *Pyrus calleryana*, *Pyrus communis*, *Pyrus fauriei*, *Pyrus lindleyi*, *Pyrus pyrifolia* var. *culta*, *Pyrus pyrifolia*, *Pyrus serrulata*, *Pyrus ussuriensis*

GEOGRAPHICAL DISTRIBUTION

Gymnosporangium asiaticum was first discovered in Japan, and it has since spread throughout Asia, including China, Japan, and South Korea. Zhuang *et al.* (2012) and Zhao *et al.* (2020) provided detailed geographic distributions of this species in China. Hiratsuka *et al.* (1992) documented the regional range of the species in Japan. Yun *et al.* (2009) listed detailed reports of this species from South Korea and the United States. In the EPPO region, *G. asiaticum* has been recorded only in the Russian Far East (Azbukina, 1984), and this single record has not been confirmed by more recent ones.



EPPO Region: Russia (Far East)

Asia: China (Anhui, Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Neimenggu, Ningxia, Shaanxi, Shandong, Shanxi, Sichuan, Xianggang (Hong Kong), Xinjiang, Xizhang, Yunnan, Zhejiang), Japan (Hokkaido, Honshu, Kyushu, Ryukyu Archipelago, Shikoku), Korea, Democratic People's Republic of, Korea, Republic of, Taiwan

North America: United States of America (California, Connecticut, New York, Oklahoma, Oregon, Washington, Wisconsin)

BIOLOGY

Gymnosporangium asiaticum, like other *Gymnosporangium* spp., is heteroecious in that it requires *Juniperus* and rosaceous hosts of the subfamily Pomoideae to complete its life cycle. Telia are produced on stems and leaves of *J. chinensis* in the spring. In moist conditions, the telia germinate *in situ* and produce basidiospores which are dispersed and are able to infect nearby *Pyrus pyrifolia* or other rosaceous hosts. Infection of *J. chinensis* by *G. asiaticum* persists for more than 1 year; indeed, infected twigs are reported to release basidiospores over many years (Aldwinckle, 1990).

Infection from basidiospores gives rise to pycnia on the upper surface of *Pyrus* leaves; they are visible from late spring to early summer. Lee (1990a) has studied the conditions needed for infection of *P. pyrifolia* leaves by sporidia from *J. chinensis*. Later, aeciospores are produced inside tubular protective sheaths (peridia) on the underside of the leaf. The aeciospores are released when the peridium ruptures and can be transported by the wind over long distances to reach *J. chinensis*. After germinating on *J. chinensis*, an overwintering latent mycelium is produced. Infection of *Pyrus* does not persist after infected leaves have fallen. The telial state appears on *J. chinensis* in the spring to begin the life cycle again. For more information see Tanaka (1922), Peterson (1967).

DETECTION AND IDENTIFICATION

Symptoms

On *Juniperus chinensis*, telia are produced on leaves and green stems (see Morphology). On *Pyrus pyrifolia*, the most conspicuous symptoms are the appearance of the aecia and pycnia on the leaves (see Morphology).

Morphology

On Aecial host:

Aecia foliicolous and caulicolous, hypophyllous, roestelioid; peridium tubular, lacerating at apex or spreading, 4–7 mm high, peridial cells linear-rhomboid, $55\text{--}103 \times 18\text{--}31 \mu\text{m}$, outer walls smooth, inner walls small papillae and side walls moderately rugose; aeciospores globose, ovoid, large coronate, $18\text{--}26 \times 14\text{--}22 \mu\text{m}$, walls yellowish, 1.0–2.0 μm thick.

On Telial host:

Uredinia absent. *Telia* foliicolous or on green stems, developing on witches' broom but without causing swelling on stem, aggregated bluntly conical, hemispherical, pulvinate or somewhat wedge-shaped; 2–6 mm high, brownish orange; teliospores 2-celled, broadly to narrowly ellipsoid, $31\text{--}50 \times 16\text{--}27 \mu\text{m}$, walls 1.0–2.5 μm , pale orange to orange, pores 1 or 2 near septum or 1 apical in upper cell; pedicels cylindrical, hyaline, 2.5–5.0 μm diam.

Details can be found in Zhao *et al.* (2020).

Detection and inspection methods

The inspection of imported *Juniperus* which may have latent infection is particularly important. A secure quarantine procedure would involve retention under closed conditions for 2 years and frequent inspection during January–May. A DNA barcode using concatenated data of rDNA ITS and LSU has already been used for detection of *G. asiaticum*, and Duan *et al.* (2020) have successfully detected *G. asiaticum* from *Juniperus chinensis* imported from Japan.

The EPPO Diagnostic Protocol for *Gymnosporangium* spp. (non-European) provides recommendations on how to detect and identify the fungus (EPPO, 2006). In addition, detection using rDNA ITS and LSU sequence data according to Duan *et al.* (2020) provides a reliable molecular diagnostic method for this pathogen.

PATHWAYS FOR MOVEMENT

Under natural conditions, spread of *G. asiaticum* is ensured by basidiospore dispersal to rosaceous hosts, and by wind-borne aeciospores to *Juniperus chinensis*. *Pyrus pyrifolia* trees within 100 m radius of a *J. chinensis* tree are at high risk of infection, and up to 1000 m in windy situations (Unemoto *et al.*, 1989). In international trade, plants of *J. chinensis* from the Far East (especially bonsai plants) are liable to be infected by *G. asiaticum*. *G. asiaticum* has been intercepted on bonsai *Juniperus* from Japan and Hong Kong (Duan *et al.*, 2020, EFSA, 2018; Henderson, 2020). As is the case for other *Gymnosporangium* spp., *G. asiaticum* can be latent during winter (the probable importing period) and may not be detectable at pre-export phytosanitary certification. Infection may also have remained latent on the plants in the previous growing season.

Introduction of *G. asiaticum* on commercial importations of plants of *P. pyrifolia* or other rosaceous hosts is very unlikely as infection is not persistent in the dormant stage. Fruits are usually not infected.

PEST SIGNIFICANCE

Economic impact

Gymnosporangium asiaticum is reported to be a serious pathogen of *Pyrus pyrifolia* in the Far East. It is also, on its alternate host, one of the most important and widely distributed fungal pathogens of urban ornamentals (*Juniperus chinensis*) in China (Zhang, 1990). There is no indication that *G. asiaticum* has any practical importance in North America, nor that it causes significant disease of any rosaceous host other than *P. pyrifolia*.

Control

As for some other *Gymnosporangium* spp., some success against *G. asiaticum* has been achieved with sterol-inhibiting fungicides, e.g. myclobutanil (Lee, 1990b). In Japan, *G. asiaticum* was mentioned among the most important target pests for a new triazole fungicide (Ohyama *et al.*, 1988). Differences in susceptibility of *P. pyrifolia* cultivar are known. Suppression of the alternate host (*J. chinensis*) within a certain radius of orchards is recommended, but may be difficult as it is often present in private gardens. Several research projects revealed that mycoparasites, such as *Tuberculina* sp., can occur on or nearby the aecia by the sporodochia and can eliminate the aeciospores before the dispersion to *Juniper* species (Huang, 1993).

Phytosanitary risk

Gymnosporangium asiaticum is one of the non-European *Gymnosporangium* spp. included in the EPPO A2 List (EPPO, 2022). At present, *G. asiaticum* is absent from most of the EPPO region (only recorded in the Russian Far East) and has occasionally been intercepted in trade on bonsai plants from Asia. It is highly probably that it could establish in Europe since its alternate host *J. chinensis* does occur. In addition, *G. asiaticum* seems to be a more damaging species on its main host *P. pyrifolia* in the Far East, than *G. sabinae* is on *P. communis* in the EPPO region. However, several factors are probably limiting the risk: 1) *P. communis*, though recorded as a host, does not appear to suffer significant damage; 2) the main host, *P. pyrifolia*, is a minor crop in the EPPO region; 3) *G. sabinae* is easily controlled and these control measures applied in pear orchards would probably be effective against *G. asiaticum*; and 4) the need for specific *Juniperus* spp. (grown only as ornamentals in Europe) to complete the life cycle could in practice severely limit the area of establishment.

PHYTOSANITARY MEASURES

As infection of *Juniperus* is systemic in stems and evergreen leaves, no chemical treatment is likely to be completely effective to treat imported plants found to be infected. It is most unlikely that infection from the telial stage could be carried on packing materials and the risk is virtually confined to infected plants. Countries may prohibit importation of plants for planting and cut branches of *Juniperus* from the Far East. If plants for planting of *J. chinensis* (or other *Juniperus* spp.) are imported from the Far East, the consignment should be kept in quarantine over the growing season and found free from *Gymnosporangium* spp. Plants for planting and cut branches of *Juniperus* from the Far East should come from a field (and its immediate vicinity) found free from diseases caused by *Gymnosporangium* species during the last two growing seasons. Particular attention should also be paid to imports of juniper bonsais from Asia, and these plants should have been produced under conditions ensuring their freedom from *G. asiaticum*. Fruits, seedlings, and cut branches of *Malus* and *Pyrus* species from the Far East, especially from China, Japan and South Korea, should be inspected to avoid the introduction of *G. asiaticum* to European regions, where Asian pears, Asian apples and *Juniperus* species have been promoted for commercial production and ornamental purposes.

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Datasheet history

This datasheet was first published in the EPPO Bulletin in 1983 and revised in the two editions of 'Quarantine Pests for Europe' in 1992 and 1997, as well as in 2022. 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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