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# *Popillia japonica*: insights into its biology, ecology as well as its impact and management in viticulture

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**Abstract:** The Japanese beetle (*Popillia japonica*) is a highly polyphagous beetle native to Northeast Asia, where it is a relatively insignificant pest. Yet, the unintentional introduction of this quarantine organism into Europe represents one of the greatest challenges facing plant protection services, agriculture and viticulture in recent years. In addition, this scarab poses also a major threat to public and private lawns in recreational spaces and parks. Unlike numerous other harmful insects recently introduced into Europe, *P. japonica* has been present in North America for over a century and there exists therefore already a wealth of knowledge on its biology, ecology and management. We summarised the available information on *P. japonica* in a recently published review dedicated to practitioners (Kehrli et al., 2025 a) and provide here deeper insights into its threat to grapevines after briefly introducing the pest and its assumed economic impact.

**Key words:** Scarabaeidae, Coleoptera, invasive species, pest control, integrated pest management

## Introduction

The Japanese beetle (*Popillia japonica* Newman) is a Scarabaeidae native to Northeast Asia that was introduced to the USA in the early 20th century. It is now widespread there and has also become locally established in Canada. While *P. japonica* is a relatively minor pest in its area of orignin, it causes in North America damage amounting to several hundred million US dollars a year (USDA, 2015). The first European record of this beetle was in the Azores in the 1970s, where it persists despite eradication measures. In 2014, *P. japonica* was recorded also in Mainland Europe, in the Milan area (EPPO, 2016). Despite eradication and containment measures, it has since spread rapidly beyond Northern Italy and was first trapped in Switzerland in 2017 in Stabio (Ticino), close to the Italian border. By the end of 2025 the Japanese beetle had colonised large parts of Ticino and the valley south of the Simplon Pass of the canton of Valais. In addition, several small, isolated populations have been found within Switzerland. Despite mandatory reporting and control requirements, it can be assumed that *P. japonica* will continue to spread in Switzerland as well as in Europe due to human activities such as the trade in plant products, and the movement of goods and people. Based on a recently published review dedicated to practitioners (Kehrli et al., 2025 a), this publication will summarise the most important information on the biology, ecology and economic impact of *P. japonica*. In addition, we will also estimate its damage potential in viticulture and highlight potential control measures.

## Biology and ecology of *P. japonica*

*Popillia japonica* generally produces one generation per year, with females laying 40 to 60 eggs throughout the summer, mainly in moist or irrigated grassland (Potter and Held, 2002; EPPO, 2006). The larvae hatch and feed on grass roots in the soil. They moult twice before winter, then burrow deeper into the soil to protect themselves from the cold. In spring, the larvae return to the root zone, where they complete their development and pupate. The next beetle generation emerges in early summer. Adults of *P. japonica*, no bigger than a one-cent coin, have an oval body with metallic golden green thorax and head and iridescent copper-coloured wing cases (EPPO, 2006). They are relatively easy to distinguish from native beetle species on account of five white tufts of hair on either side of their abdomen and two more at the tip. Identifying eggs, larvae and pupae is more challenging and requires entomological knowledge.

The host plant range of *P. japonica* encompasses more than 400 species, with adult beetles and larvae feeding on different species (EPPO, 2016; Tayeh et al., 2023; EPPO, 2024). Adult host plants include agricultural crops such as grapevines, stone fruits, apples, berries, maize, soya, beans and asparagus. Ornamental plants such as roses, wisteria and Virginia creeper and native shrubs are also attacked (EPPO, 2016). The larvae's preferred host plants include species in the genera of *Festuca*, *Poa* and *Lolium*, although they may feed on the roots of many other grasses and occasionally herbaceous plants as well (EPPO, 2016). *Popillia japonica* adults and their larvae cause non-specific feeding damage which cannot be clearly distinguished from that of native plant pests (EPPO, 2016). Holes chewed in leaves are indications of *P. japonica* adult damage and severe infestations can strip all the tissue between the leaf veins, known as skeletonising. Discoloured patches in grass and a patchy sward – both increasing over time – are signs of larval damage. Secondary damage caused by wildlife such as wild boars, badgers and crows foraging for grubs is however often more severe than the primary damage caused by *P. japonica* larvae themselves (EPPO, 2016). Moist meadows and grassland, irrigated sports grounds and recreational spaces (e. g., football pitches, golf courses, camp sites, outdoor pools, parks and gardens) and tree nurseries as well as turf growing sites are particularly at risk of larval damage.

## Economic impact of *P. japonica*

Grubs and adults of *P. japonica* can cause significant economic damage to crops and ornamental plants. The EU ranks *P. japonica* as the second most harmful quarantine organism for native crops after *Xylella fastidiosa* (Sanchez et al., 2019). Adult beetles cause primary damage by feeding on leaves, flowers and fruits. Grapevines, stone fruits, pome fruits, berries, maize, soya, hops, beans and asparagus are thought to be the most threatened agricultural crops grown in Europe and Switzerland. In addition, adult beetles also feed on ornamental plants. Since the grubs feed on grass roots in moist grassland and irrigated lawns, the *P. japonica* is the most widespread turf pest in the USA today. Besides, the roots of maize, soya and strawberries can also be affected, leading to harvest losses or even plant dieback.

In the USA, annual costs for controlling grubs and adults across all crops are estimated to be over 460 million US dollars. Losses attributable to grubs alone are estimated at 234 million US dollars per year, around one third of which is spent on controlling the pest and the rest on replacing damaged turf (USDA, 2015). Without effective control measures, the potential annual agronomic damage caused by an EU-wide infestation is estimated at up to 2.4 billion euros by Sanchez et al. (2019), while Straubinger et al. (2022) suggest a figure ranging from 30 million to 7.8 billion euros based on worst- and best-case scenarios for crops such as maize, soya, apples, peaches, cherries and grapes. Wine-producing nations such as France and Italy are particularly affected by economic damage.

## Risk and impact of *P. japonica* for grape production

The grapevine (*Vitis vinifera* L.) is one of *P. japonica*'s favourite host plants (Klein, 2022). Large numbers of adult beetles can be observed in infested Italian vineyards between June and July. As many as 200-300 beetles per vine have been recorded in Piedmont, with peaks of over 1000 adults (Bosio et al., 2022). The potential damage to the Italian wine-growing sector is estimated to be around 50 million euros per year, corresponding to roughly 75 % of the total damage caused by *P. japonica* in Italy (Straubinger et al., 2022). A socio-economic survey of Italian wine producers revealed that they anticipated increased management costs and believed a further spread of the beetle would lead to at least moderate yield and quality losses for the majority of vineyards (Straubinger et al., 2023). The authors estimate that a *P. japonica* infestation results in an average annual decrease in net income of around € 2,727 per hectare. Additional labour costs account for € 1,715 of this figure, with the rest attributable to yield losses (€ 966) and additional control costs (€ 47). While the wine producers surveyed do not expect grapevine cultivation to stop in the majority of vineyards, affected growers believe it is likely that more than a quarter of the plots will be abandoned on economic grounds. However, the survey also found that affected producers rated the resilience of their grapevines more highly than unaffected producers (Straubinger et al., 2023).

In the USA, the main flight period of *P. japonica* coincides with the ripening of grapes (BBCH 83). In particularly vulnerable vineyards, leaf area can be reduced by up to 50 % (Hammons et al., 2010 a). Minor defoliation of up to 6.5 % has no direct impact on shoot growth, yield or bunch quality (Boucher and Pfeiffer, 1989). However, severe defoliation on potted young (non-fruiting) grapevines in cages reduced subsequent carbon assimilation in the plant and soluble solids in the grapes and at the same time increased the titratable acid content of the pressed must (Boucher and Pfeiffer, 1989; Mercader and Isaacs, 2003 b). In addition, leaf damage was found to reduce the cold hardiness of newly planted grapevines (Hammons et al., 2010 b). Varietal differences also determine the susceptibility of young grapevines to *P. japonica* defoliation (Gu and Pomper, 2008; Hammons et al., 2010 a). Gu and Pomper (2008) tested 32 cultivars of different *Vitis* species and found that European and French hybrid varieties had more severe leaf damage than American varieties with *V. labrusca* heritage. The study by Hammons et al. (2010 a) also found that young vines of some varieties experienced reduced growth, accompanied by fewer bunches with fewer berries per bunch and delayed increase in sugar and pH. Conversely, other varieties of young grapevines showed little if any response to leaf damage by *P. japonica*. Overall, young grapevines of all varieties tested were able to tolerate up to 20 % defoliation (Hammons et al., 2010 a). Mercader and Isaacs (2003 a) also concluded that young *V. labrusca* var. Niagara grapevines could withstand forty beetles over two weeks. In the vineyard, leaf damage on mature grapevines increases with increasing beetle numbers. This can adversely affect the sugar content, pH, titratable acid content and phenol levels (Ebbenga et al., 2022). However, it is worth pointing out that in this experiment, in which netted 6- to 7-year-old grapevines of the variety 'Frontenac' were infested with varying densities of *P. japonica* beetles from BBCH 75 (pea-size berries) until harvesting, berry quality in the open vineyard was no different from the netted variants without captive beetles. Thus the natural rate of infestation never reached the levels of the tested variants, but with eleven beetles per grapevine it was already considerable (Ebbenga et al., 2022). Another study (Henden and Guédot, 2022) conducted in Wisconsin showed that vineyards close to pastures have higher beetle densities than those surrounded by arable land. Furthermore, the edges of vineyards were found to host more *P. japonica* adults and more severe leaf damage than the centre.

*Popillia japonica* reduce leaves to a lace-like skeleton and may even devour the entire leaf of some species. They rarely attack unripe berries (Pfeiffer, 2012), but when they do, the injured grapes may attract other pests (e. g., wasps), which then feed on them (Hammons et al., 2009). Adult beetles typically start by feeding on young leaves at the tip of the vine. Consequently, the upper parts of the foliage sustain the most leaf damage (Gu and Pomper, 2008; Pfeiffer, 2012). While mature grapevines can tolerate a certain degree of leaf damage, young vines are at risk of complete defoliation and should therefore be protected, e.g. with plastic cylinders (Pfeiffer, 2012). Overall, it is assumed that vineyards – and young grapevines in particular – close to *P. japonica* larval breeding grounds such as irrigated sports grounds and golf courses and moist grassland are most at risk and that the pest will cause the greatest damage in these areas. Although no indications have been found in the scientific literature that *P. japonica* grubs are developing in higher numbers in the understory of vineyards, grubs have been observed in profound, humid, grassy soils of vineyards of the Ticino (A. Rizzoli, unpublished data).

## Management of *P. japonica* in grape production

Successful management of *P. japonica* can only be achieved through a combination of different preventive, mechanical, physical, biological, biotechnical and chemical plant protection measures (Kehrli et al., 2025 b). The first and most important protective measure is to prevent the introduction and spread of the Japanese beetle. Care must therefore be taken when returning from infested areas and when buying plant material that could be at risk (Gotta et al., 2023). In infested areas, it is also advisable to avoid irrigating green spaces during the flight period of *P. japonica* (Allsopp et al., 1992). In addition, insect-proof nets can protect crops and potted plants from leaf damage and egg-laying. It is also possible to reduce infestation mechanically and physically by tilling (Pavasini, 2021), modifying the soil substrate (Renkema and Parent, 2021), removing adults (Switzer and Cumming, 2014), using repellents such as kaolin (Lalancette et al., 2005; Bosio et al., 2022) and adapting the host plant range close to vulnerable crops (Bohlen and Barrett, 1990; Rogers and Potter, 2004; Wood et al., 2009). However, biological pest control is key to successfully controlling *P. japonica*. The use of microorganisms is particularly promising. Specifically, these include the bacterium *Bacillus thuringiensis* var. *galleriae* (Redmond et al., 2020), entomopathogenic fungi in the *Beauveria* and *Metarhizium* genera (Behle et al., 2015; Graf et al., 2023; Wey et al., 2025) and highly specialised microsporidia (Fleming, 1972), which weaken the immune system of the larvae, thereby making them more susceptible to other pathogens. Nematodes have also proved effective at controlling larvae in the soil. Under favourable conditions, they can have an efficacy rate of over 90 % (Villani and Wright, 1988; Klein and Georgis, 1992; Marianelli et al., 2017; Torrini et al., 2020; Sciandra et al., 2024). Over the last one hundred years, more than twenty species of exotic parasitoid species have been introduced to the USA to control the beetle, although only three have successfully established (Potter and Held, 2002). Of these, the parasitoid fly *Istocheta aldrichi* and the parasitoid wasp *Tiphia vernalis* could be of particular interest for Europe. Native predators such as spiders, birds and mammals are known to feed on juvenile and adult beetles, but their non-specific diet prevents their targeted use (Potter and Held, 2002; EPPO, 2016). However, the attractants developed for monitoring *P. japonica* can also be used as biotechnological control methods, either by mass trapping (Potter and Held, 2002; Switzer et al., 2009; EPPO, 2016) or in combination with insecticide-treated nets (LLINs) (Gotta et al., 2023). Preliminary results for these two control measures are promising (Piñero and Dudenhoeffer, 2018; Paoli et al., 2023 and 2024), and both can be used within and outside cropping areas. Finally, conventional insecticides are a simple and cost-effective measure for controlling the pest quickly and effectively (Gotta et al., 2023). Italian trials have shown that the active substances acetamiprid, deltamethrin and phosmet in direct contact and in contact with surfaces treated one week previously are highly effective against adult *P. japonica* (Santoiemma et al., 2021; Bosio et al., 2022; Gotta et al., 2023).

For viticulture we consider the use of fine-meshed and well closed hail nets as particular interesting for protecting grapevine foliage from frass. Moreover, the application of kaolin and mass trapping are additional alternative measures to protect the foliage against *P. japonica* adults. In long-term studies in the USA and in Piedmont, the use of kaolin proved effective (Lalancette et al., 2005; Bosio et al., 2022). The greyish-white coating of this mineral powder based on aluminium silicate reduced grapevine leaf damage when applied at the start of the flight period, whereas repellent substances such as neem extract and zeolites were ineffective (Bosio et al., 2022). Moreover, Piñero and Dudenhoeffer (2018) set up mass traps close to elderberry and blueberry plantations in the USA thereby catching several million *P. japonica* within a three-year period and observing very few adults and foliar damage in the crops during this time. We therefore believe that mass trapping is also an interesting measure in viticulture with low risk to non-target organisms and to the environment (Kehrli et al., 2025 b). Finally, it is unlikely to us that the use of conventional insecticides against *P. japonica* adults can be completely avoided in vineyards, but spot spraying could strongly reduce the amount applied as well as residues on grapes and within proceeded wines (Kehrli et al., 2025 b). In a two-year study in commercial vineyards, Lannan and Guédot (2024) hung chemical lures in grapevines at the edge of the plots, and this peripheral area was subsequently treated with a broad-spectrum insecticide (= spot spraying). The efficacy of this approach was similar to the winegrowers' standard management practices in terms of number of adult beetles in the vineyard and leaf damage. However, it succeeded in reducing the among of insecticide applied by 96 % (Lannan and Guédot, 2024). The risk of spot spraying is however that it attracts beetles to plots with potentially low levels of infestation.

## Conclusions

The accidental introduction of *P. japonica* and its continuous spread present plant protection services and farmers with one of their greatest challenges of recent years (Kehrli et al., 2025 a). Unlike numerous other harmful insects recently introduced into Europe such as the spotted wing drosophila [*Drosophila suzukii* (Matsumura)] or the brown marmorated stink bug [*Halyomorpha halys* (Stål)], *P. japonica* has been present in North America for over a century. Accordingly, there is a wealth of knowledge available on its biology, ecology and control. Two particular points should however be emphasised: firstly, in addition to agriculture and horticulture, many public and private recreational spaces, parks and gardens are also affected. Secondly, there is a clear-cut spatial separation between the presence of eggs, larvae and pupae and of adult beetles (Kehrli et al., 2025 a). This means that plant protection measures taken against adults have little chance of succeeding if the steady supply from the often hard-to-find larval areas is not supressed at the same time. The development of sustainable protection strategies must therefore extend beyond the confines of cultivated areas and comprise a combination of different measures, even if individually, these measures are only partially effective (Kehrli et al., 2025 b). Integrated pest control strategies must consequently be adapted to suit the crops, the features of the landscape and the available host plant range.

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