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Identification of new pests likely to be introduced into Europe with the fruit trade

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Global trade of plants and plant products facilitates the international movement of pests. The introduction of new pests in an area may have huge economic consequences for local plant production, and should be avoided. The European Union (EU) imports large quantities of fresh fruit from all over the world, which could be a pathway for exotic pests. This review aimed to identify pests not yet present or regulated in the EU that may enter the territory with the fruit trade and damage fruit production in Europe. Pests of *Vaccinium* (blueberry), apple, grape, orange and mandarin were screened to assess the likelihood of their being associated with these fruit, their impact, their geographical distribution, whether they are intercepted in trade and whether they are spreading or emerging. They were further ranked to produce alert lists of 30 to 36 pests for each fruit species. These lists are presented as well as other findings on contaminants and newly introduced pests. Datasheets on those pests were prepared and are available as supporting information to this article as well as in the EPPO Global Database (https://gd.eppo.int/). This work within the EU project DROPSA aimed to raise the awareness of importers and regulatory authorities to the potential risk of introducing pests with the fruit trade.

Introduction

In 2015, around 35.8 million tonnes of fresh fruit were produced within the European Union (EU) and more than 11.2 million tonnes were imported. The EU is the world's largest importer of fresh fruit, with imports originating from more than 135 different countries (Freshfel, 2017). This creates a risk for the EU because global trade of plants and plant products facilitates the international movement of plant pests (Hulme *et al.*, 2008; Liebhold *et al.*, 2012).

Unlike many other countries in the world (e.g. the USA, Australia, New Zealand), the EU has an open phytosanitary system (Eschen *et al.*, 2015; MacLeod *et al.,* 2010). This means that before starting to import new fruit species or fruits from new areas no assessment of the risk of introducing new pests is conducted.

For many years fruits were considered to be a low phytosanitary risk in the EU compared with plants for planting because they were destined to be eaten, and were mostly imported into areas where the crops are not grown or in counter season. However, goods destined for consumption, such as fresh fruit and vegetables, are also recognized as a pathway on which pests are regularly intercepted (McCullough *et al.*, 2006; Kenis *et al.*, 2007; Lichtenberg & Olson, 2018). In recent years several pests of fruits have been introduced into the EU and caused significant damage, such as *Drosophila suzukii (*Asplen *et al.*, 2015). It has also been shown that the pattern of import has changed in the last 20 years, with producing countries importing more fruit from third countries (e.g. EFSA 2014), not only out of season, and from a much larger number of countries than before.

The EU FP7 project DROPSA ('Strategies to develop effective, innovative and practical approaches to protect major European fruit crops from pests and pathogens') ran from 2014 to early 2018 and aimed to improve plant health strategies in the fruit sector. Within this project, the European and Mediterranean Plant Protection Organization (EPPO) and the Julius-Kuehn-Institute (JKI) in Germany carried out the task 'pathways of introduction of fruit pests and pathogens', as outlined in Steffen *et al.* (2015a). An important initial step was to prepare a review of non-native pests of fruit species that have been introduced into Europe or were found in the fruit trade during the last 10–15 years. The review identified 387 pest species (see Steffen *et al.*, 2015b for details).

It should be noted that the pathway of introduction is often not known, and many pests affecting fruit species may have been introduced with plants for planting or as contaminants. However, introductions of new plant pests are likely to increase in future with the intensification of trade and the influence of climate change (Early *et al.*, 2016; Lichtenberg & Olson, 2018).

Pests (including pathogens) introduced in recent years have resulted in direct control costs for the EU, the member states and for growers as well as indirect costs through increase in product prices or export bans. It is widely recognized that prevention strategies are preferable and less

costly for the community than reaction to the introduction of new pests (including pathogens) based on eradication and containment measures. The identification of pest species of concern is a first step to design prevention strategies and to help secure fruit production systems.

This article describes the preparation of an 'alert list' of pests and pathogens likely to be introduced into the EU with the fruit trade.

Selection of fruit to be considered

A priority list of fruit crops to be considered in this study was established (see Steffen *et al.*, 2015a). Important factors for prioritizing the crops were, for example, trade volumes into the EU, the area of production in the EU, origins of trade (emerging markets) and the prior history of pest introduction (following the review described in Steffen *et al.*, 2015b). Furthermore, the overall selection aimed to provide a good geographical coverage of fruit production in the EU, to ensure a balance between fruit species (both regulated and non-regulated fruit in the EU) and to cover crops from different groups (e.g. pome fruit, stone fruit, *Citrus*, small fruit). In the course of the project, it was possible to prepare alert lists for four fruit species (see Table 1).

An attempt was made to identify emerging trade in exotic fruit that may serve as a pathway for pests, which may then transfer to fruit crops that are more widely cultivated in Europe. However, at the time of the study Eurostat data (http://ec.europa.eu/eurostat/data/database) on international trade in fruit was given at the species/genus level only for 'established' trades, whereas wider categories were used for others, such as 'other *Citrus*', 'tamarinds, cashew apples, jackfruit, lychees, sapodillo plums, passion fruit, carambola, pitahaya, other edible fruit (excl. others listed)'. A more detailed import database would be needed to allow identification of emerging trade and associated risks.

Process followed

The methodology followed for the preparation of alert lists of pests for individual fruit species was originally based on the methodology used for the EPPO tomato study (EPPO, 2015; Grousset *et al.*, 2015) and further developed in EPPO (2016). The process was adjusted during the course of the project, taking into account the experience gained. The process is described in more detail in the deliverable 'Methods for the preparation of alert lists of pests for individual fruit species' (available as Supporting Information S1). Adjustment for each fruit species is described in the relevant deliverable. The process used in this study has been used as a basis for developing EPPO Standard PM 5/9 *Preparation of pest lists in the framework of commodity PRAs* adopted in September 2017 (EPPO, 2017).

A three-step approach was followed:

- In Step 1, a worldwide list of pests for the fruit species under consideration was established, with basic information on each pest; pests that are not likely to be carried by the fruit trade are excluded from further consideration.
- In Step 2, more information is sought on remaining pests, and the pests were screened against criteria such as: whether the pest may be carried with traded fruit; whether it is present (or not) in the EU; whether it is polyphagous; climatic similarity between its areas of origin and the EU; recorded

Table 1. Fruit species selected, and justification (fresh fruit)

Vaccinium	Continuous increase of imports from outside the EU in 2002–2012 (reaching 25 000 tonnes)
	30 000 tonnes produced, commercial production extending into the north of the EU.
	Wild indigenous species also important for fruit picking and ecosystems in the EU
	Perennial crop
	Import of fruit not regulated
Apple	Second largest production area for fruit, throughout the EU (over 550 000 ha)
	Large imports (over 500 000 tonnes, rank 5 of all fruits), despite decrease
	Perennial crop
	Important crop for EU countries
	History of interceptions of pests on fruit (note: import of fruit regulated for some pests, e.g. *Carposina niponensis*, *Cydia* spp.)
Table grapes	Largest production area for fruit (incl. for wine production), throughout the EU (3.3 million ha)
	Large imports (577 000 tonnes)
	Grapevines are high-value crops (in particular for wine production)
	Perennial crop
	A few pests intercepted on fruit (import of fruit not regulated except for protected zones)
Orange and mandarins	Large production areas (>420 000 ha together)
	The largest imports among *Citrus*; 3rd and 10th fruit imports, with large volumes (over 816 000 tonnes and 317 000 tonnes)
	Widely grown in Mediterranean countries
	Perennial crop
	Large number of interceptions on fruit [import of fruit regulated in general (no leaves) and for some pests]
	Due to the importance of most *Citrus* in the EU, the study focuses on orange and mandarins, but pests of other *Citrus* species were also recorded

economic impact; previous records of interception; whether the pest is known to have spread or to be an emerging pest. An overall rating is given to each pest and the pests fulfilling high-risk criteria were selected for further consideration.

- In Step 3, pests are selected for the alert list, combining criteria as defined in Table 2, and records are prepared for the pests selected, in the format of EPPO alert list records.

Table 2. Combination of criteria ratings and sub-ratings

	Description (all pests below are associated with the fruit)
Part 1: Pests with a high economic importance and more likely to transfer	•Pests able to transfer, with a high economic impact currently (not uncertain high impact or high impact in the past)
Part 2: Pests with lesser economic importance and more likely to transfer, or with high economic importance but less likely to transfer	

All details on criteria and ratings can be found in the document describing the methods provided as Supporting Information S1.

Alert lists are divided in two parts: Part 1 including pests that have a high economic importance and are more likely to transfer, and Part 2 including those pests with lesser economic importance and that are more likely to transfer, or that have a high economic importance but are less likely to transfer. It was not thought possible to further rank pests by their level of risk in Part 2: in alert lists the pests were ordered by type (pathogen, acari, insect) and then in alphabetical order.

Results

The work on each fruit species required considerable time and effort as several hundred pests needed to be screened (see Table 3). Full reports for each fruit species are provided as Supporting Information.

Comments on the process

A number of pests already regulated in the EU were identified. They were not considered further, but it may be interesting to check whether existing measures are appropriate to cover the risk of introduction with all fruit species. For example, *Vaccinium*, whose commodities are not subject to many specific requirements, may favour the entry of major pests of other crops. The study also identified a few pests that are on EPPO lists of regulated pests but not yet regulated in the EU (*Thaumatotibia leucotreta*, which has since been regulated (EU, 2017), and *Diabrotica speciosa*).

Several Cicadellidae and Tephritidae were identified that are regulated in the EU under general categories. It could be decided whether additional species of concern should be listed by name in the plant health regulation (e.g. *Homalodisca vitripennis* for Cicadellidae).

Vaccinium

There are approximately 450 species of *Vaccinium* worldwide. The genus *Vaccinium* encompasses, in particular, species commonly called 'blueberries', 'bilberries', 'cranberries', 'lingonberries', 'huckleberries' and 'whortleberries'. There is an increasing trade in *Vaccinium* berries from outside the EU as well as substantial cropping within the EU. In addition, some wild *Vaccinium* species occur in the EU; these are important for biodiversity as well as local economies and populations. Production in the EU was about 30 000 tonnes in 2011 (imports from non-EU countries reach 25 000 tonnes). Fruits are imported regularly from more than 20 countries outside the EU. There was a general shift of origins, with major exporting countries in 2002 close to the EU (especially Russia or Belarus) being replaced by more distant countries. In particular, imports from South America have greatly increased (representing over two-thirds of imports in 2011), as well as imports from Africa.

Fruit is generally not accompanied with green parts because of quality requirements but the analysis took into account the possibility of pests associated with leaves. Fruits are generally packed in small size packages to avoid damage during transport. Blueberries are perishable and need to be transported and sold rapidly. With regard to regulated pests, the following broad categories are regulated in EU Directive 2000/29/EC (Annex I/A1) EU (2000), and any pest species under them should be considered as being already regulated in the EU: 'Tephritidae

Table 3. Number of pests considered at each steps for each fruit species studied

	Number of pests listed at each step		
Fruit	Step 1	Step 2	Alert list
Apple	1837 (incl. 50 regulated in the EU)	233	34
Vaccinium	729 (incl. 23 regulated in the EU)	411	36
Table grapes	1040 (incl. 84 regulated in the EU)	126	30
Orange and mandarins	1515 (incl. 124 regulated in the EU)	778	36

(non-European) such as', 'Cicadellidae (non-European) known to be vector of Pierce's disease (caused by *Xylella fastidiosa*)'.

The pests retained for the alert list are presented in Table 4. Pests finally listed in the alert list are mostly insects, as the possibility for pathogens to transfer was difficult to assess after consulting a limited number of references. Some pests are reported as new to the crop, in areas where the cropping of *Vaccinium* is new (such as South America). Possibly emerging pests were separated in Part 3 of the alert list.

The alert list includes 8 pests in Part 1, 17 in Part 2 and 11 in part 3. Eight pests have *Vaccinium* species as their only (or major) host.

In addition, the study identified major pests of *Vaccinium* that have already been introduced into the EU in recent years. Some still have a limited distribution (fewer than three countries) and it may be necessary to consider how to limit their further spread. They are as follows: *Blueberry red ringspot virus* (Caulimoviridae: soymovirus), *Blueberry shoestring virus* (sobemovirus), *Calonectria colhounii* (Ascomycota), *Ceroplastes cirripediformis* (Hemiptera:

Table 4. Pests likely to be associated with *Vaccinium* fruit, identified for the alert list. Details are provided in datasheets available in the report for *Vaccinium* (see Supporting Information, Appendix S2) and in the EPPO Global Database (https://gd.eppo.int/)

Pests	Distribution	Intercepted	Spreading/ emerging
Part 1: Pests with high economic importance and more likely to transfer			
Thekopsora minima (Basidiomycota)*	Africa, North America, South America, Oceania	Yes	Yes
Acrobasis vaccinii (Lepidoptera: Pyralidae)*	North America	–	Yes
Aegorhinus superciliosus (Coleoptera: Curculionidae)	South America	–	–
Argyrotaenia sphaleropa (Lepidoptera: Tortricidae)	South America	–	–
Frankliniella bispinosa (Thysanoptera: Thripidae)	North America	–	–
Phlyctinus callosus (Coleoptera: Curculionidae)	Africa, Oceania	Yes	Yes
Proeulia auraria (Lepidoptera: Tortricidae)	South America	Yes	–
Sparganothis sulfureana (Lepidoptera: Tortricidae)	North America	–	–
Part 2: Pests with lesser economic importance and more likely to transfer, or high economic importance but less likely to transfer			
Exobasidium maculosum (Basidiomycota)*	North America	–	Yes
Acalitus vaccinii (Acarida: Eriophyidae)*	North America	–	–
Acleris minuta (Lepidoptera: Tortricidae)	North America	–	–
Argyrotaenia citrana (Lepidoptera: Tortricidae)	North America	Yes	–
Aroga trialbamaculella (Lepidoptera: Gelechiidae)*	North America	–	–
Choristoneura parallela (Lepidoptera: Tortricidae)	North America	–	–
Cingilia catenaria (Lepidoptera: Geometridae)	North America	–	–
Ctenopseustis obliquana (Lepidoptera: Tortricidae)	Oceania	–	–
Epiglaea apiata (Lepidoptera: Noctuidae)*	North America	–	–
Grapholita libertina (Lepidoptera: Tortricidae)*	North America	–	–
Ochropleura implecta (Lepidoptera: Noctuidae)	North America	–	–
Orthosia hibisci (Lepidoptera: Noctuidae)	North America	–	–
Systena frontalis (Coleoptera: Chrysomelidae)	North America	–	Yes
Teia anartoides (Lepidoptera: Lymantriidae)	Oceania	Yes	Yes
Thrips obscuratus (Thysanoptera: Thripidae)	Oceania	Yes	–
Tortrix excessana (Lepidoptera: Tortricidae)	Oceania	Yes	Yes
Xylena nupera (Lepidoptera: Noctuidae)	North America	–	–
Part 3: New pests of *Vaccinium*, possibly emerging			
Diaporthe australafricana (Ascomycota)	Africa, North America, South America, Oceania	Yes	Yes
Gliocephalotrichum bulbilium (Ascomycota)	Africa, North America, South America, Caribbean, Asia	–	Yes
Accuminulia buscki (Lepidoptera: Tortricidae)	South America	Yes	–
Clarkeulia bourquini (Lepidoptera: Tortricidae)	South America	–	–
Clarkeulia deceptiva (Lepidoptera: Tortricidae)	South America	–	–
Hylamorpha elegans (Coleoptera: Scarabaeidae)	South America	Yes	–
Hyphantus sulcifrons (Coleoptera: Curculionidae)	South America	–	–
Plagiognathus repetitus (Hemiptera: Miridae)*	North America	–	–
Proeulia chrysopteris (Lepidoptera: Tortricidae)	South America	Yes (as genus)	–
Proeulia triquetra (Lepidoptera: Tortricidae)	South America	Yes (as genus)	–
Tolype innocens (Lepidoptera: Lasiocampidae)	South America	–	–

Species in bold are listed in at least one other list for the other fruits considered. Species with an asterisk (*) are oligophagous or specific to *Vaccinium*. 'distribution' is indicative at continent level (a pest may be present in only one country on this continent). 'intercepted' means that the pest has been reported as intercepted in trade, but not necessarily of *Vaccinium* fruit; 'spreading/emerging' means that the pest has extended its geographical range, is reported as invasive or as newly damaging (see datasheets for details).

Coccidae), *Colletotrichum karstii* (Ascomycota), *Diaspidiotus ancylus* (Hemiptera: Diaspididae), *Epiphyas postvittana* (Lepidoptera: Tortricidae), *Gloeosporium minus* (Ascomycota), *Neopestalotiopsis clavispora* (Ascomycota), *Oligonychus ilicis* (Acarida: Tetranychidae), *Prodiplosis vaccinii* (Diptera: Cecidomyiidae), *Pseudococcus maritimus* (Hemiptera: Pseudococcidae), *Zaprionus indianus* (Diptera: Drosophilidae).

Several pests were identified as contaminants of *Vaccinium* fruit in trade (i.e. not pests of *Vaccinium* but intercepted in consignments of *Vaccinium* fruit). Such cases were identified from South America, where their presence in *Vaccinium* fruit hinders exports to the USA. They include *Dexicrates robustus* (Coleoptera: Bostrichidae), a wood borer of many fruit species whose adults may contaminate fruit, *Frankliniella australis* (Thysanoptera: Thripidae), a polyphagous thrip of quarantine concern because of interceptions, and *Naupactus xanthographus* (Coleoptera: Curculionidae), a polyphagous pest.

Apple

Apple is the fruit of *Malus domestica*, *Malus communis* or *Malus sylvestris.* In 2012, 504 000 tonnes of apples were imported to the EU from non-EU countries, while 2.4 million tonnes of apples were traded within the EU. Between

Table 5. Pests likely to be associated with apple fruit, identified for the alert list. Details are provided in datasheets available in the report for *Apple* (see Supporting Information, Appendix S3) and in the EPPO Global Database (https://gd.eppo.int/)

Pest	Distribution	Intercepted	Spreading/emerging
Part 1: Pests with high economic importance and more likely to transfer			
Colletotrichum fructicola (Ascomycota)	Asia, North America; Africa, South America, Oceania	Yes	Yes
Aegorhinus superciliosus (Coleoptera: Curculionidae)	South America	–	–
Argyrotaenia sphaleropa (Lepidoptera: Tortricidae)	South America	–	–
Phlyctinus callosus (Coleoptera: Curculionidae)	Africa, Oceania	Yes	Yes
Proeulia auraria (Lepidoptera: Tortricidae)	South America	Yes	–
Spilonota albicana (Lepidoptera: Tortricidae)	Asia	Yes	–
Part 2: Pests with lesser economic importance and more likely to transfer, or high economic importance but less likely to transfer			
Helminthosporium papulosum (Ascomycota)*	North America	–	–
Sphaeropsis pyriputrescens (Ascomycota)*	North America	–	Yes (uncertain)
Archips argyrospilus (Lepidoptera: Tortricidae)	North America	Yes	–
Archips breviplicanus (Lepidoptera: Tortricidae)	Asia	–	–
Archips fuscocupreanus (Lepidoptera: Tortricidae)	Asia, North America	–	Yes
Archips micaceana (Lepidoptera: Tortricidae)	Asia	–	–
Archips pomivora (Lepidoptera: Tortricidae)	Asia	–	Yes
Argyresthia assimilis (Lepidoptera: Yponomeutidae)*	Asia	–	–
Argyrotaenia citrana (Lepidoptera: Tortricidae)	North America	Yes	–
Argyrotaenia pomililiana (Lepidoptera: Tortricidae)*	South America	–	–
Argyrotaenia velutinana (Lepidoptera: Tortricidae)	North America	–	–
Bonagota cranaodes (Lepidoptera: Tortricidae)	South America	–	–
Ctenopseustis obliquana (Lepidoptera: Tortricidae)	Oceania	Yes	–
Diabrotica speciosa (Coleoptera: Chrysomelidae)	South America	Yes	–
Dichocrocis punctiferalis (Lepidoptera: Crambidae)	Asia, Oceania	Yes	–
Euzophera pyriella (Lepidoptera: Pyralidae)	Asia	–	–
Lacanobia subjuncta (Lepidoptera: Noctuidae)	North America	–	–
Lygocoris communis (Heteroptera: Miridae)	North America	–	–
Lygus lineolaris (Heteroptera: Miridae)	North America	–	–
Pandemis pyrusana (Lepidoptera: Tortricidae)	North America	–	–
Platynota flavedana (Lepidoptera: Tortricidae)	North America, Caribbean	–	–
Platynota idaeusalis (Lepidoptera: Tortricidae)	North America	–	–
Pseudococcus maritimus (Hemiptera: Pseudococcidae)	North America, Asia, South America, Central America, Caribbean, Europe (indoor)	Yes	Yes
Rhynchites heros (Coleoptera: Attelabidae)	Asia	–	–
Sparganothis sulfureana (Lepidoptera: Tortricidae)	North America	–	–
Spilonota prognathana (Lepidoptera: Tortricidae)	Asia	–	–
Teia anartoides *(Lepidoptera: Lymantriidae)*	Oceania	Yes	Yes
Tortrix excessana (Lepidoptera: Tortricidae)	North America, Oceania	Yes	Yes

Species in bold are listed in at least one other alert list for the other fruits considered. Species with an asterisk (*) are oligophagous or specific to *Malus*. 'distribution' is indicative at continent level (a pest may be present in only one country on this continent). 'intercepted' means that the pest has been reported as intercepted in trade, but not necessarily of apple fruit; 'spreading/emerging' means that the pest has extended its geographical range, is reported as invasive or as newly damaging (see datasheets for details). – means that the information is not known.

2002 and 2012, apples have been imported from 70 countries in the world, with the largest number of imports being from South America and South Africa.

Since stalks are normally present on harvested apples, sometimes with attached leaves, this analysis took into account that an apple fruit on the pathway may be accompanied by green parts. Harvesting and packing procedures differ between apple producers worldwide.

Several pests are currently already regulated in the EU in relation to apple fruit, but these are mainly pests from North America and Asia, with none from South America and South Africa where most of the trade now originates.

The 34 pests retained for the alert list are presented in Table 5: 6 in Part 1 and 28 in Part 2. Most pests are polyphagous. Details are provided in datasheets available in the report for apple (see supporting information S3) and in EPPO Global Database (https://gd.eppo.int/).

During this analysis, some species have been identified that still have a very limited distribution in Europe. They were excluded from further consideration for the alert list but could be harmful for EU countries in which they do not yet occur. An example is the Australian lightbrown apple moth, *Epiphyas postvittana* (Lepidoptera: Tortricidae), which is native to Australia and was introduced to New Zealand and North America. It is now present in Ireland and the United Kingdom. *Epiphyas postvittana* is highly polyphagous and a threat to many crops including *Malus domestica*, *Citrus*, *Diospyros kaki*, *Fragaria* × *ananassa*, *Myrtus communis*, *Prunus* spp., *Pyrus communis*, *Rosmarinus officinalis*, *Rubus idaeus* and *Vitis vinifera*.

Among pests than can contaminate apple shipments, *Macchiademus diplopterus* (Hemiptera: Lygaeidae) is recorded to sometimes enter apples and pears at the calyx end and shelter deep inside the fruit. Numerous interceptions are recorded on apple, citrus, nectarine, peach, pear and plum fruits. This pest originates in South Africa and is a serious pest of cereals (wheat, oats, barley).

Table grapes

The analysis focused on table grapes as the fresh form of internationally traded and shipped grapevine fruit. The following species and their hybrids are commonly grown as fruiting species for table grape production: *Vitis vinifera*, *Vitis labrusca*, *Muscardinia rotundifolia*, *Vitis rupestris* (only as hybrid), *Vitis riparia* (only as hybrid) and *Vitis aestivalis* (only as hybrid).

Although no indication of noteworthy international trade of fresh grapes for processing was found in this project, this pathway cannot be completely excluded. It was assumed that the risks of this pathway would be equal to or less than the import of table grapes for fresh consumption because processing will destroy most pests and reduce the probability of transfer, and it is unlikely that such trade occurs over very long distances. However, grapes for processing may be of lower quality than table grapes (and therefore more infested by pests) and are more likely to be associated with plant residues (as they may be harvested mechanically).

The EU produced about 24.4 million tonnes of grapes in 2014, mainly for wine production. Table grape production in the EU represented 1.7 million tonnes and 603 000 tonnes were imported. Imports of fresh grapes from non-EU countries have substantially increased between 2002 and 2012 (by 200 000 tonnes). In 2013 the major countries exporting to the EU were South Africa, Chile, Peru, India, Egypt, Brazil, Turkey and Namibia.

Table grapes for fresh consumption in the EU are always traded as bunches/clusters composed of fleshy berries (grapes), pedicels (stalk of the single fruit) and peduncle (stalk of the fruit cluster). The complex structure of the grape bunch increases the ability of small and medium-sized pest organisms to hide within the bunch and escape detection. The marketing Directive of the EU for fresh fruit and vegetables (543/2011; Part 9) regulates the quality requirements for table grapes for fresh consumption after preparation and packaging. With regard to regulated pests, the following broad categories are regulated in EU Directive 2000/29/EC (Annex I/A1) EU (2000), and any species under them should be considered as being already regulated in the EU: 'Non-European viruses and virus-like organisms of *Vitis* L', 'Tephritidae (non-European)', 'Cicadellidae (non-European) known to be vector of Pierce's disease (caused by *Xylella fastidiosa*)'. Vectors of *X. fastidiosa* are also addressed under emergency measures in Commission Implementing Decision (EU) 2015/789 of 18 May 2015.

This study aimed to identify organisms that are associated exclusively with bunches of table grapes (berries, pedicels and peduncle) and not pests associated only with leaves. Table grapes may be stored for several months at low temperature and in a modified atmosphere and may be fumigated with sulphur dioxide.

The 30 pests retained for the alert list are presented in Table 6: 12 in Part 1 and 18 in Part 2. Details are provided in datasheets available in the report for table grapes (see Supporting Information, Appendix S1) and in the EPPO Global Database (https://gd.eppo.int/). It should also be stressed that very limited information was available from some areas, especially Africa, which prevented the identification of potentially important pests from this area. It should be noted that *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) has now been regulated as a quarantine pest by the EU (EU, 2017).

The study also identified pests that have already been introduced into the EU but still have a limited distribution. It may be necessary to consider how to limit their further spread. They are as follows: *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae), *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae), *Planococcus minor* (Hemiptera: Pseudococcidae), *Urophorus humeralis* (Coleoptera: Nitidulidae).

In addition, a large number of species are intercepted in table grapes as hitchhikers or contaminants (i.e. *Vitis* is not

Table 6. Pests likely to be associated with table grapes, identified for the alert list. Details are provided in datasheets available in the report for Table grapes (see Supporting Information, Appendix S4) and in the EPPO Global Database (https://gd.eppo.int/).

Pest	Distribution	Intercepted	Spreading/emerging
Part 1: Pests with high economic importance and more likely to transfer			
Alternaria viticola (Ascomycota: Pleosporales)*	Asia	–	–
Physalospora baccae (Ascomyceta: Xylariales)*	Asia	–	–
Xanthomonas campestris pv. *viticola* (Xanthomonadales: Xanthomonadaceae)	South America, Asia	Yes	Yes
Argyrotaenia sphaleropa (Lepidoptera: Tortricidae)	South America	–	–
Harrisina brillians (Lepidoptera: Zygaenidae)*	North America	Yes	–
Marmara gulosa (Lepidoptera: Gracillariidae)	North America, Caribbean	–	–
Paralobesia viteana (Lepidoptera: Tortricidae)*	North America	–	–
Phlyctinus callosus (Coleoptera: Curculionidae)	Africa, Oceania	Yes	Yes
Proeulia auraria (Lepidoptera: Tortricidae)	South America	Yes	–
Retithrips syriacus (Thysanoptera: Thripidae)	North America, Africa, South America, Caribbean	Yes	Yes
Rhipiphorothrips cruentatus (Thysanoptera: Thripidae)	Asia	–	–
Zaprionus indianus (Diptera: Drosophilidae)	Africa, Asia, North America, South America, Central America	Yes	Yes
Part 2: Pests with lesser economic importance and more likely to transfer, or high economic importance but less likely to transfer			
Accuminulia buscki (Lepidoptera: Tortricidae)	South America	Yes	–
Aleurolobus taonabae (Hemiptera: Aleyrodidae)	Asia	–	–
Amyelois transitella (Lepidoptera: Pyralidae)	North America, Central America, South America	Yes	Yes
Argyrotaenia citrana (Lepidoptera: Tortricidae)	North America	Yes	–
Argyrotaenia velutinana (Lepidoptera: Tortricidae)	North America	–	–
Brevipalpus chilensis (Acarida: Tenuipalpidae)	South America	Yes	–
Carpophilus davidsoni (Coleoptera: Nitidulidae)	Oceania	Yes	Yes
Cotinis nitida (Coleoptera: Scarabaidae)	North America	Yes	–
Dichocrocis punctiferalis (Lepidoptera: Crambidae)	Asia, Oceania	Yes	–
Naupactus xanthographus (Coleoptera: Curculionidae)	South America	Yes	Yes
Nipaecoccus viridis (Hemiptera: Pseudococcidae)	Africa, Asia, Oceania, North America	Yes	–
Nippoptilia vitis (Lepidoptera: Pterophoridae)*	Asia	–	–
Platynota stultana (Lepidoptera: Tortricidae)	North America, Europe (restricted distribution)	Yes	Yes
Platyptilia ignifera (Lepidoptera: Pterophoridae)*	Asia	–	–
Proeulia chrysopteris (Lepidoptera: Tortricidae)	South America	Yes (as genus)	–
Proeulia triquetra (Lepidoptera: Tortricidae)	South America	Yes (as genus)	–
Pseudococcus maritimus (Hemiptera: Pseudococcidae)	North America, Asia, South America, Central America, Caribbean, Europe (indoor)	Yes	Yes
Thaumatotibia leucotreta (Lepidoptera: Tortricidae)	Africa, Asia	Yes	Yes

Species in bold are listed in at least one alert list for the other fruits considered. Species with an asterisk (*) are oligophagous or specific to *Vitis*. 'distribution' is indicative at continent level (a pest may be present in only one country on this continent). 'intercepted' means that the pest has been reported as intercepted in trade, but not necessarily of table grapes; 'spreading/emerging' means that the pest has extended its geographical range, is reported as invasive or as newly damaging (see datasheets for details).

one of their host plants). A large proportion of these species are spiders, and this includes some species that could be of concern for human health. Ants are another group frequently intercepted on table grapes. Pest of other crops intercepted in table grapes in trade include *Proteuxoa comma* (Lepidoptera: Noctuidae), *Gryllus assimilis* (Orthoptera: Gryllidae) and *Macchiademus diplopterus* (Hemiptera: Lygaeidae).

Oranges and mandarins

Oranges and mandarins were selected to establish an alert list of pests that may present a risk to cultivated species or varieties in the EU. It was also decided that other *Citrus* species would be kept in mind, to take account of the general importance of *Citrus* in the EU and the fact that pests often affect several *Citrus* species. Orange and mandarin are the *Citrus* species that are the most imported in the EU, and represent a large cropping area (>420 000 ha together). The common names 'oranges' and 'mandarins' apply to a wide variety of species and hybrids: oranges belongs to either sweet oranges (species, varieties and hybrids of *Citrus sinensis*) or sour oranges (species, varieties and hybrids of *Citrus* × *aurantium*), mandarins are *Citrus reticulata* and some of its hybrids.

Imports of orange occur from all regions of the world, with a total of over 730 000 tonnes being imported in 2014 (against over 2 million tonnes within the EU). Considering quantities over 100 kg, oranges were imported from 52 countries in 2002, and 42 in 2008 and 2014. For mandarins, imports also occur from all regions of the world, with a total of over 176 000 tonnes in 2014 (against over 1.6 million tonnes within the EU). Considering quantities over

Table 7. Pests likely to be associated with orange and mandarin, identified for the alert list. Details are provided in datasheets available in the report for orange and mandarin (see Supporting Information, Appendix S5) and in the EPPO Global Database (https://gd.eppo.int/)

Pest	Distribution	Intercepted	Spreading/emerging
Part 1: Pests with high economic importance and more likely to transfer			
Amyelois transitella (Lepidoptera: Pyralidae)	North America, Central America, South America	Yes	Yes
Citripestis sagittiferella (Lepidoptera: Pyralidae)*	Asia	Yes	Yes
Ecdytolopha aurantianum (Lepidoptera: Tortricidae)	Central America, Caribbean, South America	Yes	–
Marmara gulosa (Lepidoptera: Gracillariidae)	North America, Caribbean	–	–
Proeulia auraria (Lepidoptera: Tortricidae)	South America	Yes	–
Resseliella citrifrugis (Diptera: Cecidomyiidae)*	Asia	–	Yes
Thaumatotibia leucotreta (Lepidoptera: Tortricidae)	Africa, Asia	Yes	Yes
Zaprionus indianus (Diptera: Drosophilidae)	Africa, Asia, North America, South America, Central America	Yes	Yes
Part 2: Pests with lesser economic importance and more likely to transfer, or high economic importance but less likely to transfer			
Brevipalpus chilensis (Acarida: Tenuipalpidae)	South America	Yes	–
Eotetranychus kankitus (Acarida: Tetranychidae)	Asia	–	–
Eotetranychus sexmaculatus (Acarida: Tetranychidae)	Asia, Oceania, North America, South America	–	Yes
Tuckerella knorri (Acarida: Tuckerellidae)	Asia, Central America, Caribbean	–	Yes
Adoxophyes cyrtosema (Lepidoptera: Tortricidae)	Asia, Oceania	–	–
Archips argyrospilus (Lepidoptera: Tortricidae)	North America	Yes	–
Argyrotaenia sphaleropa (Lepidoptera: Tortricidae)	South America	–	–
Biprorulus bibax (Hemiptera: Pentatomidae)*	Oceania, Asia	–	Yes
Coscinoptycha improbana (Lepidoptera: Carposinidae)	Oceania	–	Yes
Cryptothelea variegata (Lepidoptera: Psychidae)	Asia	–	–
Ctenopseustis obliquana (Lepidoptera: Tortricidae)	Oceania	Yes	–
Deudorix isocrates (Lepidoptera: Lycaenidae)	Asia	–	–
Diaprepes abbreviatus (Coleoptera: Curculionidae)	North America, Caribbean	Yes	Yes
Dichocrocis punctiferalis (Lepidoptera: Crambidae)	Asia, Oceania	Yes	–
Egira curialis (Lepidoptera: Noctuidae)	North America	–	–
Erthesina fullo (Hemiptera: Pentatomidae)	Asia	Yes	–
Leptoglossus zonatus (Hemiptera: Coreidae)	North America, Central America, South America	–	Yes
Lobiopa insularis (Coleoptera: Nitidulidae)	North America, Central America, South America, Europe (only Canary islands)	–	Yes
Neosilba zadolicha (Diptera: Lonchaeidae)	South America	–	–
Nipaecoccus viridis (Hemiptera: Pseudococcidae)	Africa, Asia, Oceania, North America	Yes	–
Paracoccus burnerae (Hemiptera: Pseudococcidae)	Africa, Asia	Yes	Yes
Paracoccus marginatus (Hemiptera: Pseudococcidae)	Africa, Asia, Caribbean, North America, Central America, South America	Yes	Yes
Platynota flavedana (Lepidoptera: Tortricidae)	North America, Caribbean	–	–
Praelongorthezia praelonga (Hemiptera: Ortheziidae)	Africa, Caribbean, Central America, South America; North America	Yes	Yes
Prays endocarpa (Lepidoptera: Yponomeutidae)*	Asia, Oceania	–	–
Prays endolemma (Lepidoptera: Yponomeutidae)*	Asia	–	–
Proeulia chrysopteris (Lepidoptera: Tortricidae)	South America	Yes (as genus)	–
Pseudococcus maritimus (Hemiptera: Pseudococcidae)	North America, Asia, South America, central America, Caribbean, Europe (indoor)	Yes	Yes

Species in bold are listed in at least one alert list for the other fruits considered. Species with an asterisk (*) are oligophagous or specific to *Citrus*. 'distribution' is indicative at continent level (a pest may be present in only one country on this continent). 'intercepted' means that the pest has been reported as intercepted in trade, but not necessarily of orange and mandarin; 'spreading/emerging' means that the pest has extended its geographical range, is reported as invasive or as newly damaging (see datasheets for details).

100 kg, mandarins were imported from 39 countries in 2002, 33 in 2008 and 34 in 2014.

Pests associated with leaves were all excluded because *Citrus* fruit imported into the EU should be free from peduncles and leaves (according to EU Directive 2000/29/EC, EU, 2000). Nevertheless, there is no such requirement within the EU (except for specific Protected Zones), and such fruit with leaves may constitute a pathway once such pests are introduced into the EU.

The 36 pests retained for the alert list are presented in Table 7. However, it should be noted that a larger number of pests may potentially be associated with *Citrus* fruit. Many were not retained mainly because they did not have mobile life stages, and therefore the likelihood of transfer of pests to hosts at destination from infested fruit consignments was considered as low.

In addition, the study made an attempt to differentiate pests that are present only indoors in the EU, in order to

not exclude them and identify possible risks for *Citrus* production should such pests move to outdoors crops or be newly introduced outdoors. There are known examples of pests that were first introduced indoors and later reached *Citrus* orchards. For example, *Chrysomphalus aonidum* (Hemiptera: Diaspididae) was initially known as a pest of ornamentals indoors; it was first recorded on *Citrus* trees outdoors in 1999, and is currently established in *Citrus* orchards in several European countries. Pests identified include *Ceroplastes cirripediformis* (Hemiptera: Coccidae), *Aspidiotus destructor* (Hemiptera: Diaspididae) and *Pseudococcus cryptus* (Hemiptera: Pseudococcidae).

A few pests of interest with a restricted distribution in the EU are also listed in the specific deliverable (see Supporting Information, Appendix S1) with supporting information: *Mycosphaerella aurantia* (Ascomycota), *Araecerus fasciculatus* (Coleoptera: Anthribidae), *Aspidiotus destructor* (Hemiptera: Diaspididae), *Atherigona orientalis* (Diptera: Muscidae), *Aulacaspis tubercularis* (Hemiptera: Diaspididae), *Ceroplastes cirripediformis* (Hemiptera: Coccidae), *Penthimiola bella* (Hemiptera: Cicadellidae), *Pseudococcus cryptus* (Hemiptera: Pseudococcidae).

Discussion

A large number of pests were identified as being potentially associated with the fruits studied. This may justify the requirement for a phytosanitary certificate to be issued, at least for these fruits prior to import of the fruit into the EU. According to the EU Directive 2000/29/EC (EU, 2000), fruit of *Citrus*, *Malus* and *Vaccinium* originating in non-European countries should already be subject to a plant health inspection in the country of origin or the consignor country before being permitted to enter the Community (Annex V – Part B). This could also be a requirement for table grapes.

It would be useful if EPPO countries record (and report) interceptions of non-regulated pests so that pest risk analysis or specific requirements may be considered for intercepted pests.

A number of treatments (in orchards, post-harvest during storage or transport) are applied to fruit and may reduce pest pressure, and therefore limit the likelihood of introduction. However, it was not possible to take them into account as mandatory in this analysis as fruits are imported from a wide range of countries where practices vary.

For *Vaccinium* and apple, a large number of pests associated with green parts may justify a requirement that consignments of fruit should be free from leaves (as this is already required for *Citrus* fruit and table grapes). An in-depth analysis was not conducted to check whether current practices in exporting countries already ensure this to a sufficient extent.

In addition, the large number of pests associated with either green parts, wood or roots would justify phytosanitary requirements for plants for planting of *Vaccinium*. Imports of plants for planting of *Vitis* and *Citrus* are prohibited, as well as import of *Malus* from several origins.

The likelihood of transfer from fruit consignments to other hosts is higher if infested fruit consignments are imported into facilities close to where plants are grown. The analysis was not made of whether this is a common practice in the EU for all fruit studied. This may be less of a problem for *Vaccinium* than for other fruit as they are often imported in small sized packages, but some repacking may nevertheless occur in the EU. However, as in the case of the EPPO tomato study (EPPO, 2015), this emphasizes the need to separate import and packing facilities from facilities where plants are produced, and the need to have appropriate management of waste if fruit has to be discarded after import.

A quantitative model for trade pathway analysis of plant pest entry and transfer to a host in EU territory has been developed during the DROPSA project and may be used to identify countries and products with a high risk profile for a given pest and to elaborate preventive strategies (Holt *et al.*, 2017).

Similar studies may be conducted for other fruits and will probably identify a similar number of pests of concern. It was not possible to conduct the analysis on more than four fruit commodities in the framework of this project, but pests from the alert lists that are also relevant for other crops and some other pests of concern for other fruit species that were identified during the study are listed in the deliverable 'Other interesting findings'.

This study underlines the need for preliminary analysis of risk before importing consignments of plant products. Commodity analyses prior to authorizing imports are a good way to encourage exporting countries to provide additional information to facilitate their exports. This approach can also identify pests that may have not been identified by any current systems in place to identify emerging risks (such as the EPPO Alert List; EPPO 2018). Both approaches are complementary.

The new EU Regulation 2016/2031 (EU, 2016) on protective measures against pests of plants, that should enter into force on 13 December 2019, allows a more precautionary approach with the possibility to prohibit the introduction of high-risk commodities based on a preliminary assessment pending a risk assessment being carried out (Article 42). These high-risk plants, plant products and other objects will be listed in implementing acts to be adopted by end of 2018. The work presented in this article may be used, after thorough consideration and in case such an approach is chosen and agreed upon by the EU Commission and the EU Member States, to support the listing of those fruits as high-risk plant products.

Article 49 of regulation 2016/2031 (EU, 2016) allows the implementation of 'Temporary measures concerning plants, plant products and other objects likely to pose newly identified pest risks or other suspected phytosanitary risks'. This project identified pests in countries for which imports are currently limited. They are 'newly identified pest risks' and may be considered for the design temporary measures as suggested by Article 49.

Dissemination of project outputs

DROPSA alert lists are being used in the framework of EPPO to raise awareness of pests that may be associated with fruit consignments. Short datasheets for all pests on the alert lists are available in the EPPO Global Database. The EPPO Panel on Phytosanitary Measures was presented with the results of this project at its meeting in November 2017 and, as a first step, it was decided to add several pests to the EPPO Alert List. Specific pest risk analysis may also be conducted in due course. Furthermore, there is a high interest in these lists from the plant protection services of EU Member States.

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Identification de nouveaux organismes nuisibles susceptibles d'être introduits en Europe par le commerce des fruits

Le commerce mondial de végétaux et de produits végétaux facilite la circulation d'organismes nuisibles à travers le monde. L'introduction de nouveaux organismes nuisibles dans une zone peut avoir d'énormes conséquences économiques sur la production locale de ces plantes et doit être évitée. L'Union Européenne importe de grandes quantités de fruits frais en provenance du monde entier, ce qui pourrait être une filière d'entrée pour des organismes nuisibles exotiques. Cette analyse visait à identifier les organismes nuisibles pas encore présents ni réglementés dans l'UE qui pourraient entrer sur le territoire par le commerce de fruits et nuire à la production fruitière en Europe. Les organismes nuisibles des *Vaccinium* (myrtille), de la pomme, du raisin, de l'orange et de la mandarine ont été étudiés afin d'évaluer la probabilité qu'ils soient associés à ces fruits, leur impact, leur répartition géographique, s'ils sont interceptés dans le commerce et s'ils se disséminent ou bien émergent. Ils ont ensuite été notés pour produire des listes d'alerte de 30 à 36 organismes nuisibles pour chaque espèce fruitière. Ces listes sont présentées ainsi que d'autres résultats sur les contaminants et les organismes nuisibles nouvellement introduits. Des fiches informatives sur ces organismes nuisibles sont disponibles en tant qu'informations supplémentaires à cet article, elles sont consultables dans la base de données de l'OEPP (EPPO Global Database: www.gd.eppo.int). Ce travail, effectué dans le cadre du projet européen DROPSA, visait à sensibiliser les importateurs et les autorités réglementaires au risque potentiel d'introduction d'organismes nuisibles par le commerce des fruits.

Новые вредные организмы, которые вероятно могут быть интродуцированы в Европу в ходе торговли фруктами

Мировая торговля растениями и растительными продуктами способствует международному перемещению вредных организмов. Следует избегать интродукции новых вредных организмов в зону, т.к. оно может иметь огромные экономические последствия для местного производства. Европейский Союз импортирует большое количество свежих фруктов со всего мира, что может быть путем распространения неаборигенных вредных организмов. Целью настоящего обзора было выявление вредных организмов, которые еще не присутствуют (и не регулируются) в ЕС, но которые могут проникнуть на его территорию в ходе торговли фруктами и навредить плодоводству в Европе. Вредные организмы на плодах родов *Vaccinius, Malus, Vitis* и *Citrus* были подвергнуты скринингу. Целью скриннинга была оценка: могут ли эти вредные организмы быть связаны с фруктами; их воздействие; географическое распространение; выявляются ли они в торговле; распространяются ли они и/или представляют ли новую проблему. Затем они были ранжированы для составления сигнальных перечней от 30 до 36 вредных организмов для каждого вида плодовых. Представлены эти списки, а также другие данные, например о засоряющих и недавно интродуцированных вредных организмах. По этим вредным организмам были подготовлены сводки данных, которые доступны в качестве вспомогательной информации к этой статье, а также в Глобальной базе данных ЕОКЗР ("http://www.gd.eppo.int"). Эта работа в рамках проэкта ЕС DROPSA ставила целью предупредить импортеров и контролирующие органы о потенциальном риске интродукции вредных организмов при торговле фруктами.

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Supporting Information

Appendix S1. Methods for the preparation of alert lists of pests for individual fruit species.
Appendix S2. a. Report on *Vaccinium*.
b. *Vaccinium* deliverable.
Appendix S3. a. Report on Apple.
b. Apple deliverable.
Appendix S4. a. Report on Table grapes.
b. Table grapes deliverable.
Appendix S5. a. Report on Orange and Mandarin.
b. Orange and Mandarin deliverable.