Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

PLANT SCIENCE SCAN

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BACKGROUND: The Plant Health Science Directorate of the Canadian Food Inspection Agency routinely scans external sources to identify information that might be of possible regulatory significance or interest to Canada's national plant health. This Plant Science Scan report was prepared by the Canadian Food Inspection Agency's staff as a mechanism to highlight potential items of interest, raise awareness and share significant new information related to plant health.

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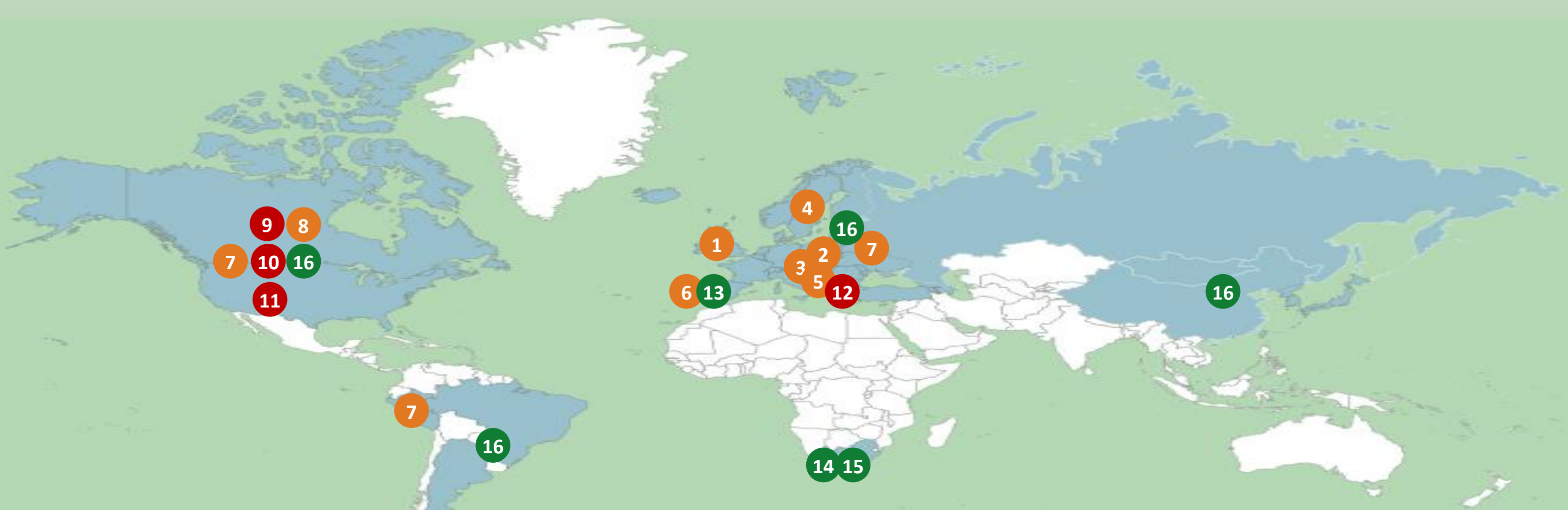

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Pathology

1 New hosts of *Hymenoscyphus fraxineus*, the causal agent of ash dieback

In a recent report, *Hymenoscyphus fraxineus* (synonym: *Chalara fraxinea*), the causal agent of ash dieback, was isolated from cultivated *Phillyrea angustifolia* (narrow-leaved mock privet), *P. latifolia* (mock privet), and *Chionanthus virginicus* (white fringetree) plants in the United Kingdom. This is the first report of *H. fraxineus* on these hosts.

Hymenoscyphus fraxineus also infects *Fraxinus* spp. (ash) and has been reported from parts of Europe and Asia. This pathogen is not known to occur in Canada and is regulated by the CFIA. Plants for planting, seeds, and wood are considered likely pathways for long-range spread of *H. fraxineus*.

Phillyrea angustifolia, *P. latifolia*, and *Chionanthus virginicus* are ornamental species in the same family as ash (*Oleaceae*). At least one species (*C. virginicus*- native to North America) is cultivated in British Columbia and Ontario and possibly elsewhere in Canada. Therefore, these new host records may represent additional pathways for the introduction and spread of this pathogen.

SOURCES: DEFRA. 2018. Ash dieback found on three new host species of tree in the UK. Department for Environment, Food & Rural Affairs (DEFRA). August 7, 2018. Last accessed August 16, 2018, from https://www.gov.uk/government/news/ash-dieback-found-on-three-new-host-species-of-tree-in-the-uk--2.

USDA-ARS. 2018. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. [Online] Available: https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysimple.aspx [2018].

2 A reclassification of *Pectobacterium* strains to *Pectobacterium polaris*

Pectobacterium spp. are considered ubiquitous plant pathogens causing soft rot, stem wilt and blackleg disease in potato. Losses are extensive and can occur during crop development, transportation of the commodity or crop storage (Toth et al. 2011). A considerable amount of work has been done over the past 40 years to classify the many species of this economically important genus (Gardan et al. 2003). The acceptance of reclassifications has not been forthcoming such as the renaming of *Erwinia carotovora* subsp. *carotovora* to *P. carotovorum* subsp. *carotovorum* (Hauben et al. 1998). More recently, some *Pectobacterium carotovorum* strains originating from the Netherlands and Norway were reclassified as a new species, *Pectobacterium polaris* (Dees et al. 2017).

In Poland, over 250 isolates collected since 1995 showing symptoms of soft rot were sequenced to determine if new *Pectobacterium* species was present and if strains have been misidentified (Waleron 2018). This was done using multilocus sequence analysis of five housekeeping genes. Five strains from potato and one from bittersweet were considered distinct from *P. carotovorum* subsp. *carotovorum* and renamed *P. polaris*. This is the first report of soft rot caused by *P. polaris* in Poland. The earliest sample now identified as *P. polaris* dates back to 1996. *Pectobacterium* spp., the causal agents of soft rot of potato, are regulated, non-quarantine pests under the Canadian Seed Potato Certification Program.

SOURCES: Dees, M.W., et al., 2017. *Pectobacterium polaris* sp. *nov*., isolated from potato (*Solanum tuberosum*). International Journal of Systematic and Evolutionary Microbiology 67: 5222-5229

Gardan, L., et al. 2003. Elevation of three subspecies of *Pectobacterium carotovorum* to species level: *Pectobacterium atrosepticum* sp. *nov.*, *Pectobacterium betavasculorum* sp. *nov.* and *Pectobacterium wasabiae* sp. *nov.* International Journal of Systematic and Evolutionary Microbiology, 53, 381–391.

Hauben, L. et al. 1998. Phylogenetic position of phytopathogens within *Enterobacteriaceae*. Systematic and Applied Microbiology, 21:384-397.

Motyka, A., et al. 2017. Molecular methods as tools to control plant diseases caused by *Dickeya* and *Pectobacterium* spp: A minireview. New Biotechnology 39: 181-189.

Toth, I. K., et al. 2011. *Dickeya* species: an emerging problem for potato production in Europe Plant Pathol. 60:385.

Waleron, M. et al. 2018. First Report of *Pectobacterium polaris* Causing Soft Rot of Potato in Poland. Plant Disease 08/2018.

Weber, Z. 1991. Relationship between the occurrence of black leg and potato tuber rot. Prace z Zakresu Nauk Rolniczych. 71:141-146.

3 New host for *Candidatus* Phytoplasma mali

Candidatus Phytoplasma mali (apple proliferation phytoplasma, 16SrX-A group) was detected for the first time on sour cherry (*Prunus cerasus* L.) in the Czech Republic, expanding the known host range of this phytoplasma (Fránová et al. 2017). This phytoplasma is known to experimentally and naturally infect a wide range of hosts, including but not limited to wild and ornamental *Malus* spp. (apple), *Cuscuta* spp. (dodder), *Nicotiana* spp., *Apium graveolens* (celery), *Solanum lycopersicum* (tomato), *Convolvulus arvensis* (bindweed), *Corylus avellana* (hazel), *Prunus salicina* (Japanese plum), *P. avium* (sweet cherry), *Pyrus* spp. (pear), and *Quercus* spp. (oak) (Seemüller et al. 2011). *Candidatus* Phytoplasma mali is regulated in Canada for its effects on apples.

SOURCES: Fránová, J., Lenz, O., Přibylová, J., Špak, J., Koloniuk, I., Suchá, J. and Paprštein, F. 2017. "*Candidatus* Phytoplasma asteris" and "*Candidatus* Phytoplasma mali" strains infecting sweet and sour cherry in the Czech Republic. Journal of Phytopathology 166(1):59-66.

Seemüller, E., Carraro, L., Jarausch, W. and Schneider, B. 2011. Apple proliferation phytoplasma. Virus and virus-like diseases of pome and stone fruits:67-75.

4 Studies on seed transmission of *Hymenoscyphus fraxineus*

Hymenoscyphus fraxineus is the fungus that causes ash dieback, a disease responsible for large-scale population declines of European ash (*Fraxinus excelsior*) and narrow-leafed ash (*Fraxinus angustifolia*) in Europe (McMullan et al. 2018). In 2012, Cleary et al. detected *H. fraxineus* in surface-sterilized *F. excelsior* seeds, suggesting that the fungus is seed-borne in ash. Based in part on this information, Canada implemented phytosanitary measures in 2013 to prohibit the importation of nursery stock, branches, and seeds of *Fraxinus* spp. from all countries infested with *H. fraxineus*. However, despite detecting the fungus in F. excelsior seeds, Cleary et al. (2012) did not investigate if the fungus was seed-transmissible in F. excelsior (i.e. if infected seeds germinate to produce infected seedlings). Recently, to examine this, Marčiulynienė et al. (2017) germinated *F. excelsior* seeds that contained seed-borne *H. fraxineus* and tested the resulting plants for the presence of *H. fraxineus*. The authors grew nearly 1800 F. excelsior seedlings from seed lots that had between 11% and 56% incidence of *H. fraxineus* and failed to detect *H. fraxineus* in any of the seedlings. This provides the first evidence that *H. fraxineus* is not seed-transmitted. Nevertheless, the fungus can be present on seeds and the ability of the fungus to sporulate on seeds is unknown; molecular seed testing and seed treatment may mitigate this risk (Marčiulynienė et al. 2017).

SOURCES: **Cleary, M. R., Arhipova, N., Gaitnieks, T., Stenlid, J. and Vasaitis, R. 2012.** Natural infection of *Fraxinus excelsior* seeds by *Chalara fraxinea*. Forest Pathology 43(1):83-85.

Marčiulynienė, D., Davydenko, K., Stenlid, J., Shabunin, D. and Cleary, M. 2017. *Fraxinus excelsior* seed is not a probable introduction pathway for *Hymenoscyphus fraxineus*. Forest Pathology 48(1):e12392.

McMullan, M., Rafiqi, M., Kaithakottil, G., Clavijo, B. J., Bilham, L., Orton, E., Percival-Alwyn, L., Ward, B. J., Edwards, A., Saunders, D. G. O. and others. 2018. The ash dieback invasion of Europe was founded by two genetically divergent individuals. Nature Ecology & Evolution 2(6):1000-1008.

5 *Candidatus* Phytoplasma fragariae

Candidatus Phytoplasma fragariae was recently detected causing dieback, witches' broom, and death of *Corylus avellana* (hazelnut) trees in Slovenia (Mehle et al. 2018). This phytoplasma belongs to the 16SrXII-E group and was first described on *Fragaria × ananassa* (strawberries) in Lithuania in 2006 (Valiūnas et al. 2006). Since then, it has been reported causing symptoms of chlorosis, dieback, leaf rolling, and witches' broom on diverse hosts in several countries, including *Cornus sanguinea* (common dogwood) and *Sambucus nigra* (elder) in Italy (Filippin et al. 2008), *Cordyline* in the United Kingdom (UK) (Hodgetts et al. 2008), *C. avellana* in the UK (Hodgetts et al. 2015), and *Solanum tuberosum* (potato) in China (Cheng et al. 2015; Cheng et al. 2012). Further, in China, this phytoplasma was reported to increase in incidence over a five-year period in potato fields (Cheng et al. 2012), although no vectors have been identified and the ability of *Ca.* P. fragariae to spread in Canada remains unknown. Nevertheless, the ability of *Ca.* P. fragariae to kill hazelnut trees (Hodgetts et al. 2015; Mehle et al. 2018), infect strawberries (Valiūnas et al. 2007; Valiūnas et al. 2006), and spread and reduce potato yield (Cheng et al. 2015; Cheng et al. 2012) suggests that this phytoplasma could be a potential concern to these industries in Canada. Currently, *Ca. P. fragariae* is not a regulated pest for Canada.

SOURCES: **Cheng, M., Dong, J., Lee, I.-M., Bottner-Parker, K. D., Zhao, Y., Davis, R. E., Laski, P. J., Zhang, Z. and McBeath, J. H. 2015.** Group 16SrXII phytoplasma strains, including subgroup 16SrXII-E ('*Candidatus* Phytoplasma fragariae') and a new subgroup, 16SrXII-I, are associated with diseased potatoes (*Solanum tuberosum*) in the Yunnan and Inner Mongolia regions of China. European Journal of Plant Pathology 142(2):305-318.

Cheng, M., Dong, J., Zhang, L., Laski, P. J., Zhang, Z. and McBeath, J. H. 2012. Molecular characterization of stolbur group subgroup E (16SrXII-E) phytoplasma associated with potatoes in China. Plant Disease 96(9):1372-1372.

Filippin, L., Angelini, E. and Borgo, M. 2008. First identification of a phytoplasma infecting *Cornus sanguinea* and *Sambucus nigra*. Plant Pathology 57(6):1175.

Hodgetts, J., Boonham, N., Mumford, R., Harrison, N. and Dickinson, M. 2008. Phytoplasma phylogenetics based on analysis of secA and 23S rRNA gene sequences for improved resolution of candidate species of '*Candidatus* Phytoplasma'. International Journal of Systematic and Evolutionary Microbiology 58(8):1826-1837.

Hodgetts, J., Flint, L. J., Davey, C., Forde, S., Jackson, L., Harju, V., Skelton, A. and Fox, A. 2015. Identification of '*Candidatus* Phytoplasma fragariae' (16Sr XII-E) infecting Corylus avellana (hazel) in the United Kingdom. New Disease Reports 32:3.

Mehle, N., Ravnikar, M., Dermastia, M., Solar, A., Matko, B. and Mešl, M. 2018. First report of '*Candidatus* Phytoplasma fragariae' infection of *Corylus avellana* (hazelnut) in Slovenia. Plant Disease:1-4.

Valiūnas, D., Jomantienė, R. and Davis, R. E. 2007. Phytoplasmas detected in cultivated fruit plants in Lithuania. Bulletin of Insectology 60(2):139-140.

Valiūnas, D., Staniulis, J. and Davis, R. E. 2006. '*Candidatus* Phytoplasma fragariae', a novel phytoplasma taxon discovered in yellows diseased strawberry, *Fragaria×ananassa*. International Journal of Systematic and Evolutionary Microbiology 56(1):277-281.

6 First report of *Meloidogyne luci* naturally infecting potato in Portugal

Meloidogyne luci is a newly described species of root-knot nematode (Carneiro et al. 2014) and recently, several populations of *M. ethiopica* reported in Europe were reclassified as *M. luci* (Gerič Stare et al. 2017). This nematode is a potentially polyphagous species that has been reported on several important plant species such as bean, broccoli, cucumber, grapevine, soybean and tomato (EPPO 2016).

In a recent publication, *M. luci* was isolated from potato roots in Portugal; this is the first report of this nematode naturally infecting potato worldwide (Maleita et al. 2018). The pathogenicity of *M. luci* to potato was evaluated on 16 commercial cultivars and compared with *M. chitwoodi*, a quarantine pest of Canada and many other countries. All potato cultivars were susceptible to both nematode species, although *M. luci* tended to be less aggressive than *M. chitwoodi*. The results of this study indicate that *M. luci* may be a species of emerging significance for the economically important potato crop.

Currently, *Meloidogyne luci* is not a regulated pest for Canada.

SOURCES: Carneiro, R. M., Correa, V. R., Almeida, M. R. A., Gomes, A. C. M., Deimi, A. M., Castagnone-Sereno, P. and Karssen, G. 2014. *Meloidogyne luci* n. sp.(Nematoda: Meloidogynidae), a root-knot nematode parasitising different crops in Brazil, Chile and Iran. Nematology 16(3):289-301.

EPPO. 2016. Previous finding of *Meloidogyne ethiopica* in Slovenia is now attributed to *Meloidogyne luci*. EPPO Reporting Service No 11, 2016/212.

Gerič Stare, B., Strajnar, P., Susič, N., Urek, G. and Širca, S. 2017. Reported populations of *Meloidogyne ethiopica* in Europe identified as *Meloidogyne luci*. Plant Disease 101(9):1627-1632.

Maleita, C., Esteves, I., Cardoso, J., Cunha, M., Carneiro, R. and Abrantes, I. 2018. *Meloidogyne luci*, a new root-knot nematode parasitizing potato in Portugal. Plant Pathology 67(2):366-376.

CFIA Scientist Publication

7 The linear mitochondrial genome of the quarantine chytrid *Synchytrium endobioticum*; insights into the evolution and recent history of an obligate biotrophic plant pathogen

This recent publication describes a comparative study of the mitogenomes from several isolates of the potato wart pathogen *Synchytrium endobioticum* originating from various locations in Europe, Canada, and South America. It established that mitochondrial genotypes did not show direct association with pathotypes or origin, and that the same pathotype can emerge independently in different lineages. It was also demonstrated that this pathogen can evolve quickly, shifting pathotype, and overcoming host resistance when cultured through semi-resistant varieties.

SOURCE: Bart T.L.H. van de Vossenberg; Balázs Brankovics; Hai D.T. Nguyen; Marga P.E. van Gent-Pelzer; Donna Smith; Kasia Dadej; Jarosław Przetakiewicz; Jan Kreuze; Margriet Boerma; Gerard C.M. van Leeuwen; André C. Lévesque; Theo A.J. van der Lee. 2018. The linear mitochondrial genome of the quarantine chytrid *Synchytrium endobioticum*; insights into the evolution and recent history of an obligate biotrophic plant pathogen. BMC Evolutionary Biology 18:136.
Quick Link: https://rdcu.be/6hNc

8 Simulating the impacts of climate change on soybean cyst nematode and the distribution of soybean

Soybean is the 4th largest crop in the world in terms of cultivated area and the 6th in terms of production yield (FAOSTAT 2017). Production rankings are comparable in Canada with an estimated 7.5 million metric tonnes in 2018 (Statistics Canada 2018). Soybean cyst nematode (SCN), *Heterodera glycines* Ichinohe, is a major agricultural pest of soybean, causing over $1 billion USD in annual losses for the United States alone (Wrather and Koenning 2009).

It is expected that in response to climate change, there will be an expansion of where soybean can be cultivated, as well as SCN. Furthermore, environmental changes may lead to decreased ability of soybeans to cope with parasites, like SCN. Modelling studies are useful when it comes to predicting the potential effects of climate change on agricultural production.

Gendron St-Marseille et al. (2019) used reference air and soil temperatures for Québec agricultural land between1980-2010 (air temperatures for the soybean model and soil temperatures for the SCN model). Their modelling accounted for different potential atmospheric greenhouse gas concentration trajectories, using two different scenarios. These represent an "intermediate" (1.1^0C-2.6^0C mean surface temperature increase and 650 ppm average atmospheric CO2 concentration by the year 2100) and a "pessimistic" (2.6^0C-4^0C mean surface temperature increase and 1390 ppm average atmospheric CO2 concentration by the year 2100) scenario. For each scenario, they ran 10 global climate model scenarios for the period 2041-2070 (referred to as the "2050 horizon"). After running the simulations, they used the 10th percentile of the results as a "warmer" scenario and the 90th percentile as the "cooler" scenario to illustrate the inter-annual variation between simulations within each of the "intermediate" and "pessimistic" scenarios.

Under various combinations of warmer/cooler scenarios, it was predicted that soybean could be planted from 15-35 days earlier in the 2050 horizon. Harvest time would be affected too – ranging from 14 days earlier in southern Québec and 28 days earlier in northern Québec.

The number of SCN generations per growing season was also predicted to increase from 3 to possibly 6 generations. Importantly, there are also predictions that in the current northern limits of soybean growth, where SCN cannot currently reproduce or survive, SCN will be capable of producing 2-3 generations in all evaluated northern regions by the 2050 horizon.

The authors applied their simulation results in a case study at an experimental site to illustrate the application of the model, showing specific examples of changes in planting and harvesting dates for soybeans and SCN seasonal population dynamics.

The results of these scenarios suggest expanded northerly range and lengthened growing season for soybean, as well as an increased range and more generations per growing season for SCN. This information could be used to inform a number of programs administered by the CFIA in regards to plant health initiatives.

SOURCES: FAOSTAT (2017). 2014 World Production Quantity of Primary Crops. Retrieved from http://faostat.fao.org

Gendron St-Marseille AF, Bourgeois G, Brodeur J, Mimee B (2019) Simulating the impacts of climate change on soybean cyst nematode and the distribution of soybean. Agricultural and Forest Meteorology 264: 178–187. https://doi.org/10.1016/j.agrformet.2018.10.008

Statistics Canada (2019) Table 32-10-0359-01 Estimated areas, yield, production, average farm price and total farm value of principal field crops, in metric and imperial units

Wrather JA, Koenning SR (2009) Effects of diseases on soybean yields in the United
States 1996 to 2007. Plant Health Progress 10(1): 1–8.
https://apsjournals.apsnet.org/doi/10.1094/PHP-2009-0401-01-RS

Entomology

9 Pine shoot beetle, *Tomicus piniperda* (Linnaeus): analysis of regulatory options for Canada

The Canadian Food Inspection Agency (CFIA) requested this analysis from the Canadian Forest Service (CFS). The request was triggered by a similar study conducted by the USDA-APHIS on the effectiveness of the mitigation program against the pine shoot beetle in the USA. The purpose of this research was to assess the cost-benefit of the current programme in Canada against the possible financial losses if no control measures are in place. The results will be used by the CFIA in the decision making process about the official control of *Tomicus piniperda*.

SOURCE: Bogdanski, B.E.C., Corbett, L., Dyk, A., Grypma, D. 2018. Pine shoot beetle, *Tomicus piniperda* (Linnaeus): analysis of regulatory options for Canada. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre.

10 Negative impact of white fringetree, *Chionanthus virginicus*, on biocontrol of emerald ash borer (Coleoptera: Buprestidae)

By serving as a refuge for EAB, it has become imperative that the presence of white fringetree in an EAB-infested area deserves some attention with regard to whatever management plan is put in place. If control methods deployed against EAB are successful in ash tree stands, this success can be reversed by the stands being re-infested by beetles from the white fringetree stands.

Emerald ash borer is a regulated quarantine pest in Canada. It has been reported from Ontario and Quebec, and new detections have recently been reported from New Brunswick, Nova Scotia, and Manitoba. Because of its devastating impact on ash trees, EAB has been acknowledged as the single most destructive forest pest that has invaded North America.

SOURCES: Olson, D. G. and Rieske, L. K. 2018. Host range expansion may provide enemy free space for the highly invasive emerald ash borer. Biological Invasions, pp. 1-11.

Cipollini, D. 2015. White fringetree as a novel larval host for emerald ash borer. Journal of Economic Entomology, 108: 370–375.

11 *Phytomyza gymnostoma* established in North America

This regulated pest for Canada (risk assessment 2014-34) can decimate Allium crops in North America too, as it has done in Europe. It is present now in New York, Pennsylvania, New Jersey and likely in Delaware and Maryland. It has been in the U.S. since at least 2015 when samples were sent for identification from Pennsylvania. Trapping is of limited value, according to the authors, but hand collecting and netting is a valuable way to determine presence.

SOURCE: Barringer, L. E., Fleischer, S. J., Roberts, D., Spichiger, S.-E. and Elkner, T. 2018. The first North American record of the allium leafminer. Journal of Integrated Pest Management 9(1): 8; 1–8
https://doi.org/10.1093/jipm/pmx034

12 First record of *Xylotrechus chinensis* (Coleoptera, Cerambycidae) in Greece and in the EPPO region

The current distribution of the Tiger longicorn beetle in Europe includes Spain and Greece (Crete). In Asia the species is present in China, Japan, Democratic Republic of Korea, Republic of Korea and Taiwan. The species is not reported as a pest in China. In Europe the pest has been reported on mulberry trees until now. Feeding activity disrupts the transportation of water and nutrients, weakens the tree and may result in its death. The preference is for old trees. *X chinensis* infests healthy trees, but the larvae may develop on cut trees as well (EPPO Alert List 2018).

The pest has showed invasive behaviour in Spain (particularly in Catalonia) and is present in an area of at least 44,1km^2 where the infestation level is between 10 and 45%. It is estimated that the species got established around 2012 (Sarto i Monteys and Torras i Tutusaus 2018).

Morus spp. (mulberries) are considered major hosts, but *Malus* spp. (apple), *Pyrus* spp. (pear) and *Vitis vinifera* (grapevine) are considered as hosts in some publications, even though direct evidence has not yet confirmed this information (EPPO Alert List 2018). Trade of infested plants is considered as the main pathway for dissemination. There are at least 3 confirmed interceptions in trade: Germany intercepted 2 adults (male and female) on wood packaging material (marked as treated with methyl bromide) from China, USA intercepted the species on wooden spools holding steel wire rope from China and again an interception in Germany in a container of wooden decoration items (made of Betula and Salix – which are not considered hosts) from China (EPPO Alert List 2018; Sarto i Monteys and Torras i Tutusaus 2018).

SOURCES: EPPO Alert List. 2018. *Xylotrechus chinensis* (Coleoptera: Cerambycidae). [Online] Available: https://www.eppo.int/ACTIVITIES/plant_quarantine/alert_list_insects/xylotrechus_chinensis # [22 Oct. 2018].

Leivadara, E., Leivadaras, I., Vontas, I., Trichas, A., Simoglou, K., Roditakis, E. and Avtzis, D. N. 2018. First record of *Xylotrechus chinensis* (Coleoptera, Cerambycidae) in Greece and in the EPPO region. Bulletin OEPP/EPPO Bulletin 48 (2), 277–280

Sarto i Monteys, V. and Torras i Tutusaus, G. 2018. A New Alien Invasive Longhorn Beetle, *Xylotrechus chinensis* (Cerambycidae), Is Infesting Mulberries in Catalonia (Spain). Insects 9(2):52.

Botany

13 *Campylopus introflexus*, an invasive moss in North America

Until recently, bryophytes (mosses, liverworts, hornworts) have received little attention in the field of invasion biology. Factors affecting their invasive potential may differ from those of vascular plants, which have been extensively studied. For instance, their production of wind-dispersed spores allows for dispersal across greater distances than the seeds of most plants. They are less likely to be introduced intentionally, due to their low ornamental and economic value, and are less likely to be detected in early stages of invasion.

Campylopus introflexus (Hedw.) Brid. is the most well-studied invasive bryophyte and is considered one of the 100 worst alien species in Europe. A moss native to the Southern Hemisphere, *Campylopus introflexus* was first discovered in England in 1941 and on the mainland (France) in 1954, after which it quickly expanded its distribution in all directions. The plants form dense mats or cushions which threaten sensitive lichen-dominated plant communities in dunes, grasslands and disturbed peat bogs. Its impacts to these ecosystems also negatively affect grasshoppers, beetles, spiders and birds. Knowledge of this species and its impacts in Europe continues to increase. In a recent study, Sérgio et al. (2018) explored potential linkages between human-induced changes and the invasion pattern of *Campylopus introflexus* in Portugal. They found that the invasion potential of this species was strengthened in areas with dense human populations and in non-native forest plantations, whereas colonization was hindered in areas where fire and agricultural practices promote dryness.

Much less is known about the invasion of *Campylopus introflexus* in western North America, where its distribution is rapidly expanding as well. It was discovered in California in 1967 and has since been found in Oregon, Washington and southwestern British Columbia. In British Columbia, it is known from a few locations (e.g., bogs) near the southwestern coastline, where it appears to be outcompeting other bryophytes and lichens. Carter (2014) provides baseline information on the distribution and ecological preferences of *Campylopus introflexus* in North America and notes that "[w]hile nothing is known about the potential of the species to impact the native flora in western North America, negative impacts in similar European ecosystems are well documented and should serve as a warning." An assessment of *Campylopus introflexus* by the CFIA determined that it qualifies as a potential quarantine pest. However, there are currently no measures known to counteract the spread of this species.

SOURCES: Carter, B. E. 2014. Ecology and distribution of the introduced moss *Campylopus introflexus* (Dicranaceae) in western North America. Madroño 61(1): 82-86.

Essl, F., Steinbauer, K., Dullinger, S., Mang, T. and Moser, D. 2014. Little, but increasing evidence of impacts by alien bryophytes. Biological Invasions 16: 1175-1184.

Sérgio, C., Garcia, C. A., Stow, S., Martins, A., Vieira, C., Hespanhol, H. and Sim-Sim, M. 2018. How are anthropogenic pressures facilitating the invasion of *Campylopus introflexus* (Dicranaceae, Bryopsida) in Mainland Portugal? Cryptogamie, Bryologie 29(2): 283-292. https://doi.org/10.7872/cryb/v39.iss2.2018.283

14 South Africa releases national report on biological invasions

The South African National Biodiversity Institute recently released its first comprehensive national status report on the country's invasive alien species (Van Wilgen and Wilson 2018). The report was required by law, based on regulations passed in 2014 that mandate a national review of invasive species every 3 years. Pioneering in scope, the report was compiled by 37 authors and editors from 14 organizations and examines all aspects of biological invasions in the country including pathways of introduction, effectiveness of interventions, and costs to the nation's economy and environment. According to Wild (2018) this is the first comprehensive synthesis of the state of invasive species by any country; and it paints a dire picture, with invasive species costing the country approximately 6.5 billion rand (US$450 million) a year and responsible for about a quarter of its biodiversity loss. Invasive species also pose a threat to South Africa's water resources, a serious concern in a country prone to drought conditions that are expected to worsen with climate change.

The report uses a system of 21 indicators that will be re-visited every 3 years. Key findings include:
• 2034 alien species are established outside cultivation or captivity in South Africa, 775 of which are invasive and 107 of which cause significant negative impacts on the environment.
• Most were deliberately introduced for agriculture, forestry, horticulture, aquaculture and the pet trade, and the rate of introduction (both intentional and unintentional) is increasing, currently estimated at 7 new species per year.
• 75% of invasive species with severe impacts are terrestrial or freshwater plants, with the remaining 25% including 8 mammals, 5 freshwater vertebrates (e.g, fish), 5 terrestrial invertebrates, one marine species, 2 amphibians and 1 bird.
• Environmental impacts include degradation of rangelands, reduced surface water runoff and groundwater recharge, increased fire hazards and decreased biodiversity; and the unique Fynbos biome is particularly at risk.

The report will serve as a baseline for assessing trends and setting management targets. It concludes that it "should be imperative to improve management efficiency, given the substantial economic and social consequences that would be associated with a failure to adequately address the problem of biological invasions" (Van Wilgen and Wilson 2018).

SOURCES: Van Wilgen, B.W. and Wilson, J.R. (Eds.) 2018. The status of biological invasions and their management in South Africa in 2017. South African National Biodiversity Institute, Kirstenbosch and DST-NRF Centre of Excellence for Invasion Biology, Stellenbosch, South Africa. 398 pp.

Wild, S. 2018. South Africa's invasive species guzzle water and cost US$450 million a year. Nature 563: 164-165. https://doi.org/10.1038/d41586-018-07286-0.

15 *Centranthus ruber*, a potentially invasive ornamental plant

Escape from horticulture is one of the most important pathways for the introduction and spread of invasive plant species and those that are deliberately planted by humans are often the most troublesome invaders. As such, urban centres can serve as points of introduction from which invasive plants can spread to nearby natural areas. *Centranthus ruber* (L.) DC. (red valerian) is a widely cultivated ornamental plant native to the Mediterranean and introduced in many parts of the world where it has naturalized and become invasive (e.g., Australia, New Zealand, Europe, and parts of North and South America). It is highlighted by Geerts et al. (2017) as an emerging invader in South Africa, where it has been grown in and around Cape Town for more than a century but is recently reported to be spreading outside of cultivation. Surveys reported 64 naturalized populations in 2013 and 530 by the end of 2015, with increases attributed to both spread and greater awareness. Of particular concern is its ability to cross over from urban to wildland habitats and establish in near-pristine areas, including one population found in Table Mountain National Park. A weed risk assessment (WRA) conducted for this species using the Australian WRA method resulted in a score of 14 ("reject" or high risk) and a species distribution model for South Africa found large parts of the country to be climatically suitable for establishment. The study emphasizes the importance of monitoring common ornamental species with invasive traits, and managing and legislating emerging invaders at the urban-wildland interface.

In North America, *Centranthus ruber* is sold as an ornamental (University of Minnesota 2018) and has naturalized on the west coast of the U.S., in Arizona, California, Oregon, Utah and Washington (USDA-NRCS 2018). In Canada it is reported only from British Columbia, where it was collected once in Victoria, but is not considered established (Klinkenburg 2015).

SOURCES: Geerts, S., Rossenrode, T., Irlich, U. M. and Visser, V. 2017. Emerging ornamental plant invaders in urban areas – *Centranthus ruber* in Cape Town, South Africa as a case study. Invasive Plant Science and Management 10: 322-331. https://doi.org/10.1017/inp.2017.35.

Klinkenburg, B. 2015. E-Flora BC: Electronic Atlas of the Plants of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver, BC. [Online] Available: http://www.geog.ubc.ca/biodiversity/eflora/index.shtml [Cited 2018].

University of Minnesota 2018. Plant information online. [Online] Available: https://plantinfo.umn.edu/ [Cited 2018].

USDA-NRCS 2018. The PLANTS database. National Plant Data Team, Greensboro, NC 27401-4901 USA. [Online] Available: http://plants.usda.gov [Cited 2018].

16 Global rise in emerging alien species due to new source pools

The ability to predict which species will become invasive relies heavily on evidence of prior introductions elsewhere and most pest risk assessment models require evidence of invasiveness to evaluate potential impacts. Likewise, the global trend towards increasing numbers of alien species introductions has been largely attributed to drivers such as increased trade and travel, globalization and habitat degradation, suggesting that the same pool of invasive alien species may be profiting from increased opportunities for dispersal and establishment. However, new evidence from a global database meta-analysis suggests a high proportion of species in recent introduction records are emerging alien species that have never been recorded as aliens before, and that this cannot be explained entirely by well-known drivers. Rather, it is also the result of new regions being incorporated into the global source pools of potential alien species, due to expanding trade networks and environmental change.

In a recent study, Seebens et al. (2018) analyzed a global database of 45,984 regional first records of 16,019 established alien species from most major taxonomic groups (plants, mammals, birds, fish, insects, crustaceans, molluscs and other invertebrates) for the years 1500-2005. Despite centuries of alien species introductions they found that one quarter of first records in the years 2000-2005 were still “emerging” alien species, reported for the first time as alien outside their native range. They note that a high number of species had very few records in the database, illustrating that most alien species will not spread widely and become invasive as per the tens rule (e.g., see Williamson and Fitter 1996). However, they also suggest that a high number and proportion of emerging species in a region indicates likely starting points for further spread, identifying hotspots of predicted future increases in invasion threats in Europe, North America and East Asia, as well as in emerging economies such as Brazil and Argentina. High numbers of alien species introductions in general, and emerging aliens in particular, were explained by increases in candidate species pools, as well as traditional drivers such as greater import volumes and land degradation in recipient regions. They conclude that the introduction of new alien species is still ongoing at high rates, and that many more invasions can be predicted in future, with large and emerging economies being likely starting points for future spread. This poses a particular challenge to biosecurity programs that rely on evidence of invasiveness elsewhere, and highlights the need to improve the predictive ability of prevention and risk assessment tools.

SOURCES: Seebens, H., Blackburn, T. M., Dyer, E. E., Genovesi, P., Hulme, P. E., Jeschke, J. M., Pagad, S., Pyšek, P., van Kleunen, M., Winter, M., Ansong, M., Arianoutsou, M., Bacher, S., Blasius, B., Brockerhoff, E. G., Brundu, G., Capinha, C., Causton, C. E., Celesti-Grapow, L., Dawson, W., Dullinger, S., Economo, E. P., Fuentes, N., Guénard, B., Jäger, H., Kartesz, J., Kenis, M., Kühn, I., Lenzner, B., Liebhold, A. M., Mosena, A., Moser, D., Nentwig, W., Nishino, M., Pearman, D., Pergl, J., Rabitsch, W., Rojas-Sandoval, J., Roques, A., Rorke, S., Rossinelli, S., Roy, H. E., Scalera, R., Schindler, S., Štajerová, K., Tokarska-Guzik, B., Walker, K., Ward, D. F., Yamanaka, T. and Essl, F. 2018. Global rise in emerging alien species results from increased accessibility of new source pools. Proceedings of the National Academy of Sciences 115(10): E2264-E2273. https://doi.org/10.1073/pnas.1719429115

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