EPPO Datasheet: *Bactericera cockerelli*

Last updated: 2020-10-08

Bactericera cockerelli is a pest in itself (feeding damage), and it transmits '*Candidatus* Liberibacter solanacearum' to solanaceous plants.

IDENTITY

Preferred name: *Bactericera cockerelli*
Authority: (Šulc)
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Hemiptera: Sternorrhyncha: Triozidae
Other scientific names: *Paratrioza cockerelli* (Šulc), *Trioza cockerelli* Šulc
Common names: potato psyllid, tomato psyllid
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EPPO Categorization: A1 list
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EU Categorization: Quarantine pest ((EU) 2019/2072 Annex II A)
EPPO Code: PARZCO

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HOSTS

Bactericera cockerelli is found primarily on plants within the family Solanaceae. It attacks, reproduces, and develops on a variety of cultivated and weedy plant species (Essig, 1917; Knowlton & Thomas, 1934; Pletsch, 1947; Jensen, 1954; Wallis, 1955), including crop plants such as potato *(Solanum tuberosum)*, tomato *(Solanum lycopersicum)*, pepper *(Capsicum annuum)*, eggplant *(Solanum melongena)*, and tobacco *(Nicotiana tabacum)*, and non-crop species such as nightshade *(Solanum* spp.), groundcherry (*Physalis* spp.) and matrimony vine *(Lycium* spp.). Adults have been collected from plants in numerous families, including Pinaceae, Salicaceae, Polygonaceae, Chenopodiaceae, Brassicaceae, Asteraceae, Fabaceae, Malvaceae, Amaranthaceae, Lamiaceae, Poaceae, Menthaceae and Convolvulaceae, but this is not an indication of the true host range of this psyllid (Pletsch, 1947; Wallis, 1955; Cranshaw, 1993). In addition to solanaceous species, *B. cockerelli* has been shown to reproduce and develop on some Convolvulaceae species, including field bindweed *(Convolvulus arvensis)* and sweet potato *(Ipomoea batatas)* (Knowlton & Thomas, 1934; List, 1939; Wallis, 1955; Puketapu & Roskruge, 2011; J. E. Munyaneza, unpublished data).

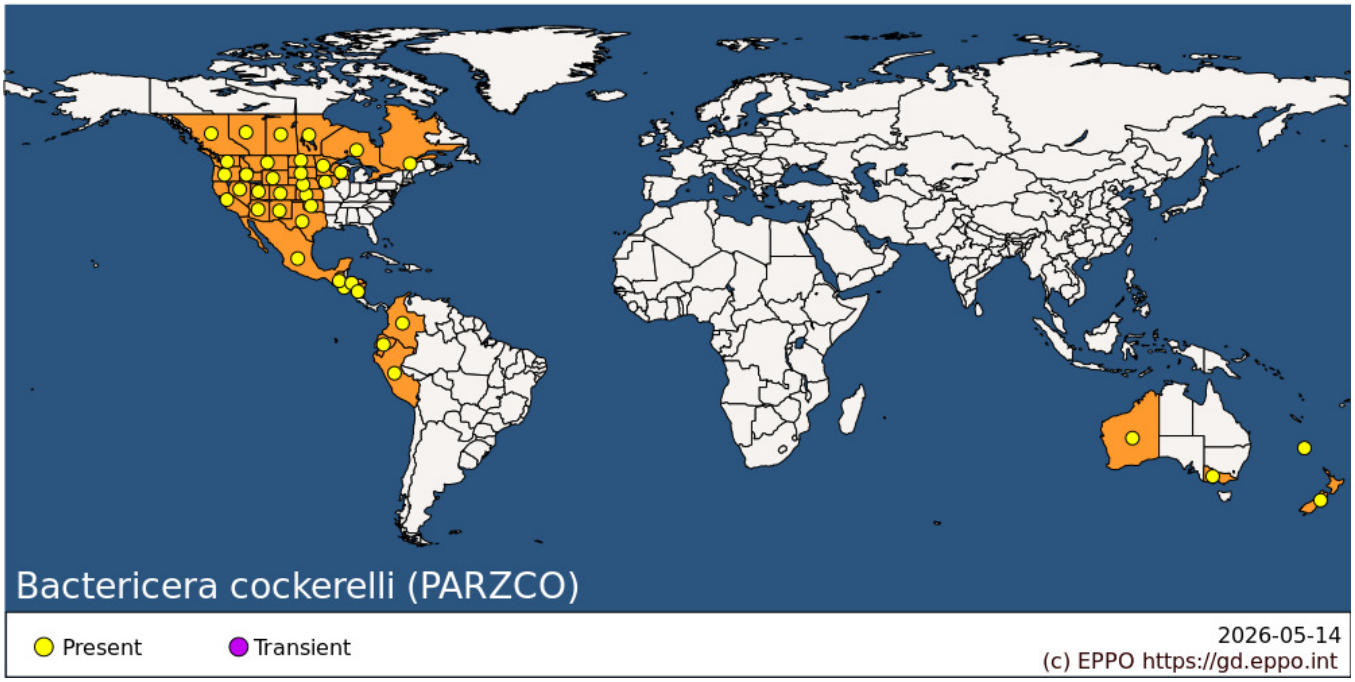
Host list: *Capsicum annuum*, *Chamaesaracha coronopus*, *Convolvulus arvensis*, *Datura stramonium*, *Ipomoea batatas*, *Lycium barbarum*, *Lycium berlandieri*, *Lycium carolineanum*, *Lycium ferocissimum*, *Mentha*, *Micromeria douglasii*, *Nepeta*, *Nicandra physalodes*, *Nicotiana tabacum*, *Physalis longifolia*, *Physalis virginiana*, *Solanum aviculare*, *Solanum dulcamara*, *Solanum lycopersicum*, *Solanum melongena*, *Solanum pseudocapsicum*, *Solanum tuberosum*

GEOGRAPHICAL DISTRIBUTION

B. cockerelli is thought to be native to South-Western USA and Northern Mexico (Pletsch, 1947; Wallis, 1955). In Canada, this psyllid may survive all year round under protected indoor conditions, but outdoor populations only occur late in the growing season, following the insect migration from Northern Mexico and the USA. *B. cockerelli* cannot overwinter in Canada and is not considered as established there. In addition, it must be noted that the pathogen '*Candidatus* Liberibacter solanacearum' has never been observed on potatoes or tomatoes in Canada (Ferguson & Shipp, 2002; Ferguson *et al.*, 2003). In the USA, the potato psyllid had previously been reported to only occur west of the Mississippi River (Richards & Blood, 1933; Pletsch, 1947; Wallis, 1955; Cranshaw, 1993; Capinera, 2001); however, this insect was recently collected on yellow sticky traps near potato fields in Wisconsin

late in the summer of 2012 (Henne *et al.*, 2012), which constitutes the first documentation of this insect east of Mississippi. Populations of *B. cockerelli* were recently found in Ecuador (South America) (Castillo Carrillo *et al.*, 2019).

In New Zealand, *B. cockerelli* was first detected in May 2006 (Gill, 2006; Teulon *et al.*, 2009; Thomas *et al.*, 2011). The first occurrence in Australia dates back in February 2017 in several private gardens and in a cultivated field in the Perth area (Western Australia). The species was considered under eradication but as early as June 2018, the psyllid was declared not eradicated and a National Plan for the management of the harmful organism was issued (IPPC website. 2017).



North America: Canada (Alberta, British Columbia, Manitoba, Ontario, Québec, Saskatchewan), Mexico, United States of America (Arizona, California, Colorado, Idaho, Iowa, Kansas, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, Wisconsin, Wyoming)
Central America and Caribbean: El Salvador, Guatemala, Honduras, Nicaragua
South America: Colombia, Ecuador, Peru
Oceania: Australia (Victoria, Western Australia), New Zealand, Norfolk Island

BIOLOGY

The eggs are laid individually on the lower or upper surface of the leaves, usually near the leaf edge, but some eggs can also be found on all above ground parts of suitable host plants. After egg hatching, the young nymphs crawl down the egg stalk to search for a place to feed.

Nymphs are found mostly on the lower surface of the leaves and usually remain sedentary during their entire development preferring sheltered and shaded locations.

Nymphs and adults produce characteristic and large quantities of small whitish excrement which may adhere to foliage and fruit. Adults are more active compared to nymphal stages. They are good fliers and readily jump when disturbed. The pre-oviposition period is normally about 10 days, with oviposition lasting up to 53 days. Total adult longevity ranges from 20 to 62 days and females usually live twice to three times as long as males, depending on which host plants they are reared on (Pletsch, 1947; Abernathy, 1991; Abdullah, 2008; Yang & Liu, 2009).

Females lay an average of 300–500 eggs over their lifetime (Knowlton & Janes, 1931; Pletsch, 1947; Abdullah, 2008; Yang & Liu, 2009). A sex ratio of 1:1 has been reported (Abernathy, 1991; Yang & Liu, 2009). *B. cockerelli* overwinters as an adult.

Weather is an important element influencing the biology of *B. cockerelli* and its potential damage to host plants. It seems to be adapted for warm, but not hot weather. Cool weather during migrations, or at least the absence of high temperatures, has been associated with several insect outbreaks (Pletsch, 1947; Wallis, 1955; Capinera, 2001; Cranshaw, 2001).

Optimum psyllid development occurs at approximately 27°C, whereas oviposition, hatching, and survival are reduced at 32°C and stop at 35°C (List, 1939; Pletsch, 1947; Wallis, 1955; Cranshaw, 2001; Abdullah, 2008). A single generation may be completed in 3–5 weeks, depending on temperature. The number of generations varies considerably among regions, usually ranging from three to seven per year. However, once psyllids invade an area, prolonged oviposition by adults may lead to overlapping generations. making it difficult to distinguish them (Pletsch, 1947; Wallis, 1955).

In North America, *B. cockerelli* appears to migrate annually primarily with wind and hot temperatures in late spring from its overwintering and breeding areas in Western Texas, Southern New Mexico, Arizona, California, and Northern Mexico to northerly regions of the USA and Southern Canada, especially through the mid-western states and Canadian provinces along the Rocky Mountains (Romney, 1939; Pletsch, 1947; Jensen, 1954; Wallis, 1955). In these regions, damaging outbreaks of *B. cockerelli* in potatoes and tomatoes occurred at regular intervals beginning in the late-1800s and extending into the 1940s (List, 1939; Wallis, 1946; Pletsch, 1947). In more recent years, outbreaks have also occurred in regions outside of the midwestern USA, including in Southern California, Baja California, Washington, Oregon, Idaho, and Central America (Trumble, 2008, 2009; Munyaneza *et al.*, 2009a; Wen *et al.*, 2009; Crosslin *et al.*, 2010, 2012a,b; Munyaneza, 2010, 2012; Butler & Trumble, 2012; Munyaneza & Henne, 2012).

At present, 3 biotypes have been described in USA: western, central and northwestern. Information on *B. cockerelli* migration movements within Mexico and Central America is lacking. In South-Western USA, potato psyllids reappear in the overwintering areas between October and November, presumably dispersing southward from northern locations (Capinera, 2001); however, their origin has not been determined.

In countries and regions where there is no winter (e.g. Mexico, Central America), temperatures are relatively cool, and suitable host plants may be available for *B. cockerelli* reproduction and development all year around. It is not known whether migration of this psyllid occurs within New Zealand.

DETECTION AND IDENTIFICATION

Symptoms

B. cockerelli has historically been associated with psyllid yellows disease of potato and tomato (Richards & Blood, 1933). Psyllid yellows disease is thought to be associated with psyllid nymphs feeding activity (List, 1925, Waters and Darner, 2017, Xia, Qing, 2017) and may be caused by a toxin associated with the insect (Carter, 1939), In the last decade, tomato psyllids have been identified as the vector of '*Candidatus* Liberibacter solanacearum' a bacterial pathogen that causes zebra chip disease in potato and vein greening disease in tomatoes (Prager and Trumble, 2018).

Above the ground, characteristic plant symptoms of infestation by *B. cockerelli* in potatoes and tomatoes include delayed growth, erectness of new foliage, chlorosis and purpling of new foliage with leaf basal cupping and upward rolling throughout the plant, shortened and thickened terminal internodes resulting in rosetting, enlarged nodes, axillary branches or aerial potato tubers. Additional symptoms are disruption of fruit set, and production of numerous small fruits of poor quality (List, 1939; Pletsch, 1947; Daniels, 1954; Wallis, 1955). Below ground, symptoms on potato include setting of excessive number of tiny misshaped potato tubers, production of chain tubers, and early breaking of tuber dormancy (List, 1939; Pletsch, 1947; Wallis, 1955).

Additional potato tuber symptoms associated with transmission of '*Candidatus* Liberibacter solanacearum' include collapsed stolons, browning of vascular tissue in combination with necrotic flecking of internal tissues and streaking of the medullary ray tissues, all of which can affect the entire tuber. Upon frying, these symptoms become more pronounced and crisps or chips processed from affected tubers show very dark blotches, stripes, or streaks, rendering them commercially unacceptable (Munyaneza *et al.*, 2007a,b, 2008; Secor *et al.*, 2009; Crosslin *et al.*, 2010; Miles *et al.*,

2010; Munyaneza, 2012; Munyaneza & Henne, 2012).

Morphology

Eggs

Eggs are oval and are connected to the leaf surface by a thin stalk. The eggs initially are light-yellow, but with time turn dark-yellow or orange. The egg measures about 0.32–0.34 mm long, 0.13–0.15 mm wide, and with a stalk of 0.48–0.51 mm. Eggs hatch 3–7 days after oviposition (Pletsch, 1947; Wallis, 1955; Capinera, 2001; Abdullah, 2008; Butler & Trumble, 2012; Munyaneza, 2012; Munyaneza & Henne, 2012).

Nymphs

Nymphs are elliptical when viewed from above, but very flattened in profile, appearing almost scale-like. *B. cockerelli* nymphs can also be confused with nymphs of whiteflies, although the former move when disturbed. Five nymphal instars can be found, each instar having very similar morphological features other than size. Nymphal body width is variable, ranging from 0.23 to 1.60 mm, depending on different instars (Rowe & Knowlton, 1935; Pletsch, 1947; Wallis, 1955; Butler & Trumble, 2012; Munyaneza, 2012; Munyaneza & Henne, 2012). Nymphs are initially orange, become yellowish-green and then green as they mature. The compound eyes are reddish and quite prominent.

During the third instar, the wing pads which are light in colour become evident and get more pronounced with each molt. A short fringe of wax filaments is present along the lateral margins of the body. Total nymphal development time ranges of 12–24 days depending on temperature and host plant (Knowlton & Janes, 1931; Abdullah, 2008; Yang & Liu, 2009).

Adult

The adults are quite small, measuring about 2.5–2.75 mm long, resembling tiny cicadas, largely because their wings are held angled and roof-like over their body (Wallis, 1955; Butler & Trumble, 2012; Munyaneza, 2012; Munyaneza & Henne, 2012). They have two pairs of clear wings, front wings being considerably larger than the hind ones. The antennae are moderately long, about the length of the thorax. Body colour ranges from pale green at emergence, to dark green or brown within 2–3 days, and grey or black thereafter. White or yellow lines are found on the head and thorax, and whitish bands on the first and terminal abdominal segments. These white markings, particularly the broad, transverse white band on the first abdominal segment and the inverted V-shaped white mark on the last abdominal segment, are distinguishing characteristics of *B. cockerelli* (Pletsch, 1947; Wallis, 1955).

Molecular

Accurate and rapid identification of pests upon first occurrence in a new area is essential to prevent spread to areas where they do not occur and to control outbreaks. *B. cockerelli* is considered a serious threat for the EPPO region so it is necessary to develop and validate diagnostic tests that allow rapid identification. Sumner-Kalkun *et al.,* (2020) designed and validated the first specific real-time PCR based on a TaqMan probe, targeting the region of the ITS2 gene of *B. cockerelli*. The test can be performed on DNA extracted from a single adult, juvenile stage- and egg. Its exclusivity was evaluated on 73 species of psyllids collected in various areas of Europe, New Zealand, Mexico and the United States including in the genus *Bactericera* other than *B. cockerelli* and the main vectors of '*Candidatus* Liberibacter solanacearum' worldwide (Summer-Kalkun *et al.,* 2020).

'*Candidatus* Liberibacter solanacearum' is present in numerous organs and tissues of *B. cockerelli*, including the alimentary canal, salivary glands, hemolymph and bacteriomas. The presence of the bacterium '*Candidatus* Liberibacter solanacearum' in vector insects can be reliably detected by conventional and real time PCR in samples of 10 individuals of *B. cockerelli* collected in the field by the use of yellow chromotropic traps or by manual collection. Details on testing on vectors are provided in PM 7/143 (EPPO, 2020a) (Cooper *et al*., 2013; Crosslin *et al.,* 2011).

PATHWAYS FOR MOVEMENT

Adults of *B. cockerelli* are good fliers and can disperse over considerable distances with the onset of wind and hot

temperatures. Adults have been shown to migrate massively to northern and western states of the USA and southern Canadian provinces in the spring from the insect overwintering sites in the South-Western USA and Northern Mexico (i.e. several hundred km). Immature stages of *B. cockerelli* are essentially sedentary and do not actively disperse. Long distance transport of different life stages of this pest is possible, mainly by commercial trade of plants of Solanaceae family, which represent major hosts for *B. cockerelli*. This pest was introduced into New Zealand probably by the transport of plant material from Western USA, possibly as eggs (Crosslin *et al.*, 2010; Thomas *et al.*, 2011). Entry on fruit of host species (e.g. tomato, pepper) is also possible, especially when they are associated with green parts (e.g. truss tomato). No life stages of *B. cockerelli* are associated with potato tubers or soil.

PEST SIGNIFICANCE

Economic impact

The extensive damage to solanaceous crops that was historically observed during the outbreak years of the early 1900s in Mid-Western USA is thought to have been due to *B. cockerelli's* association with a physiological disorder in plants referred to 'psyllid yellow'. Infected tomato plants produced few or no marketable fruit (List, 1939; Daniels, 1954). In potatoes, psyllid yellows lead to yellowing or purpling of foliage, early death of plants, and low yields of marketable tubers (Eyer, 1937; Pletsch, 1947; Daniels, 1954; Wallis, 1955). In areas of outbreaks of psyllid yellows, the disorder was often present in 100% of plants in affected fields, with yield losses exceeding 50% in some areas (Pletsch, 1947). Many of the outbreaks in the early 1900s occurred well north of the insect's overwintering range, such as the states of Montana and Wyoming (Pletsch, 1947), proving the dispersal capabilities of the psyllid.

Recently, potato, tomato, and pepper growers in a number of geographic areas have suffered extensive economic losses associated with outbreaks of *B. cockerelli* (Trumble, 2008, 2009; Munyaneza *et al.*, 2009b,c,d; Crosslin *et al.*, 2010; Munyaneza, 2010, 2012; Butler & Trumble, 2012; Munyaneza & Henne, 2012). This increased damage is due to a previously undescribed species of the bacterium Liberibacter, tentatively named '*Candidatus* Liberibacter solanacearum' (syn. '*Ca.* L. psyllaurous') (Hansen *et al.*, 2008; Liefting *et al.*, 2009), now known to be vectored by *B. cockerelli* (Munyaneza *et al.*, 2007a,b; Buchman *et al.*, 2011a,b; Munyaneza, 2012, Sengoda et. al., 2014). Potato psyllids acquire and spread the pathogen by feeding on infected plants (Munyaneza *et al.*, 2007a,b; Buchman *et al.*, 2011a,b). The bacterium is also transmitted transovarially in the psyllid (Hansen *et al.*, 2008), which contributes to spread the disease between geographic regions by dispersing psyllids and helps maintain the bacterium in geographic regions during the insect's overwintering period (Crosslin *et al.*, 2010; Munyaneza, 2012). Symptoms associated with Liberibacter in tomatoes and pepper include chlorosis and purpling of leaves, leaf scorching, stunting or death of plants, and production of small, poor-quality fruit (Liefting *et al.*, 2009; McKenzie & Shatters, 2009; Munyaneza *et al.*, 2009c,d; Brown *et al.*, 2010; Crosslin *et al.*, 2010; Butler & Trumble, 2012). During the outbreaks of 2001–2003, tomato growers in coastal California and Baja California suffered losses exceeding 50–80% of the crop (Trumble, 2009; Butler & Trumble, 2012). In potatoes, Liberibacter foliar symptoms closely resemble those caused by psyllid yellows and purple top diseases (Munyaneza *et al.*, 2007a,b; Sengoda *et al.*, 2010).

However, tubers from Liberibacter-infected plants develop a defect referred to as 'zebra chip', which is not induced by the potential toxin causing psyllid yellows (Munyaneza *et al.*, 2007a,b, 2008; Sengoda *et al.*, 2009; Wenninger *et al*, 2017). Tubers show a striped pattern of necrosis, which is particularly noticeable when the tuber is processed for crisps or chips (Munyaneza *et al.*, 2007a,b, 2008; Miles *et al.*, 2010; Wenninger *et.al*, 2017). When affected by zebra chip, potato tubers become unsuitable for processing and cannot be used in the fresh market as both the taste and the internal appearance of the tuber are altered (Vereijssen *et al.*, 2018). Such defect was of sporadic importance until 2004, when it began to cause millions of dollars in losses to potato growers in the USA, Central America, and Mexico (Rubio-Covarrubias *et al.*, 2006; Munyaneza *et al.*, 2007a, 2009b; Crosslin *et al.*, 2010; Munyaneza, 2010, 2012; Munyaneza & Henne, 2012). In some regions, entire fields have been abandoned because of zebra chip (Secor & Rivera-Varas, 2004; Munyaneza *et al.*, 2007a; Crosslin *et al.*, 2010; Munyaneza, 2010, 2012; Munyaneza & Henne, 2012). The potato industry in Texas estimates that zebra chip could affect over 35% of the potato acreage in Texas, with potential losses annually to growers exceeding 25 million USD (CNAS, 2006). Finally, quarantine issues have begun to emerge in potato psyllid-affected regions because some countries now require that shipments of solanaceous crops from certain growing regions are tested for the pathogen before the shipments are allowed entry (Crosslin *et al.*, 2010; Munyaneza, 2012; Wenninger *et al.*, 2017).

The impact of *B. cockerelli* and '*Candidatus* Liberibacter solanacearum' on agriculture is very high. Since their

arrival in New Zealand in 2005, it has caused millions of dollars in economic losses in terms of production losses, increased crop management costs and market losses export (Teulon *et al.,* 2009). The introduction of *B. cockerelli* into potato growing regions in Europe or Asia would have devastating effects on the agricultural industry in those regions. If *B. cockerelli* were to invade Europe, it is estimated that they could cause damage to the potato and tomato sector of 222 million EUR per year (Soliman, 2012).

A global scale study comparing land-use maps and environments suitable for *B. cockerelli* / '*Candidatus* Liberibacter solanacearum', showed that of the nearly 80% of the global potato production area (96 % of the potato growing area in South America, 14 % in Eurasia, 100 % in Australia) can be considered at risk of damage (Wan *et al*., 2020).

Control

Monitoring *B. cockerelli* is essential for effective management of this insect pest. Early season management is crucial to minimize damage and psyllid reproduction in the field. The adult populations are commonly sampled using sweep nets or vacuum devices, but egg and nymphal sampling requires visual examination of foliage. The adults can also be sampled with yellow water-pan traps. Typically, psyllid populations are highest at field edges initially, but if not controlled, the insects will eventually spread throughout the crop (Henne *et al.,* 2010; Butler & Trumble, 2012; Workneh *et al.,* 2012).

Bactericera cockerelli control is currently achieved by insecticide applications (Goolsby *et al.,* 2007; Gharalari *et al.,* 2009; Berry *et al.,* 2009; Butler *et al.,* 2011; Munyaneza, 2012; Butler & Trumble, 2012; Munyaneza & Henne, 2012; Guenthner *et al.,* 2012) but psyllids have been shown to easily develop insecticide resistance due to their high fecundity and short generation times (McMullen & Jong, 1971).

Therefore, alternative strategies should be considered to limit the impact of *B. cockerelli* and its associated diseases. Even with conventional insecticides, *B. cockerelli* tends to be difficult to manage. It has been determined that Liberibacter is transmitted to potato very rapidly by the potato psyllid and a single psyllid per plant can successfully transmit this bacterium to potato in 6 hours, leading to zebra chip disease (Buchman *et al.,* 2011a,b).Just a few infectious psyllids feeding on potato for a short period can result in substantial spread of the disease within a potato field or region (Henne *et al.,* 2010).

Conventional pesticides may have limited direct disease control as they may not kill the potato psyllid quickly enough to prevent bacterial transmission, although they may be useful for reducing the overall population of psyllids. The most valuable and effective strategies to manage zebra chip disease would likely be those that discourage vector feeding, such as use of plants that are resistant to psyllid feeding or less preferred by the psyllid. Unfortunately, no potato variety has so far been shown to exhibit sufficient resistance or tolerance to zebra chip or potato psyllid (Munyaneza *et al.,* 2011).

However, some conventional and biorational pesticides, including plant and mineral oils and kaolin, have shown some substantial deterrence and repellency to potato psyllid feeding and oviposition (Gharalari *et al.,* 2009; Yang *et al.,* 2010; Butler *et al.,* 2011; Peng *et al.,* 2011) and could be useful tools in integrated pest management programs to manage zebra chip and its psyllid vector

Good insecticide coverage or translaminar activity is important because psyllids are commonly found on the underside of the leaves. Insecticides controlling adults do not necessary controls nymphs or eggs. Active ingredients used in the USA against *B. cockerelli* include imidacloprid, thiamethoxam, spiromesifen, dinotefuran, pyriproxyfen, pymetrozine, and abamectin (Goolsby *et al.,* 2007; Liu & Trumble, 2007; Liu *et al.,* 2006; Butler & Trumble, 2012; Munyaneza & Henne, 2012; Guenthner *et al.,* 2012). In New Zealand, the list of products to control *B. cockerelli* includes acephate, metamidophos, imidacloprid, thiacloprid, buprofezin, abamectin, cypermethrin, deltamethrin, lambda-cyhalothrin, esfenvalerate, spinosad, and spirotetramat (Berry *et al.,* 2009).

The frequent use of neonicotinoids (group 4A) throughout the southwestern United States to control *B. cockerelli* has raised concerns about widespread resistance to such actives. By exposing the young nymphs collected in the field at different dose of two neonicotinoids, imidacloprid and thiamethoxam, it was verified that they developed resistant to both insecticides and the level of resistance depending on the geographical position of psyllids tested. Such results underline the need to diversify and integrate the strategies used in *B. cockerelli* integrated management of and reduce dependence on insecticides to manage psyllid infestations and disease (Szczepaniec *et al.,* 2019).

In the pest control strategies, it may be necessary to employ different insecticides, although this is in contrast with anti-resistance strategies (EPPO, 2020b).

B. cockerelli is affected by a large number of natural enemies, including chrysopid larvae, ladybirds, geocorids, anthocorids, myrids, nabids, syrphid larvae and the parasitoids *Tamarixia triozae* (Hymenoptera: Eulophidae) and Metaphycus psyllidis (Hymenoptera), known for their effects on psyllid populations (Pletsch, 1947; Wallis, 1955; Cranshaw, 1993, Butler *et al.*, 2010; Butler and Trumble, 2012a; Liu *et al.*, 2012). In addition, several entomopathogenic fungi, including *Beauveria bassiana*, *Metarhizium anisopliae* and *Isaria fumosorosea*, proved to be effective natural enemies of *B. cockerelli*, causing laboratory and field mortality of up to 99 and 78% respectively (Lacey *et al.*, 2009; 2011).

In New Zealand 16 native strains of entomopathogenic fungi used against adults and nymphs of *B. cockerelli* were selected. In laboratory tests, a strain of *Beauveria bassiana* (ICMP 8701) resulted in high mortality in first instar nymphs and young adults. These results allow to consider *B. bassiana* ICMP 8701 as a component in the integrated management of the *B. cockerelli* in New Zealand- (Liu *et al*., 2020). *Tamarixia triozae* (Burks) is an important parasitoid of *B. cockerelli* which has been evaluated for use as a biological control agent of the psyllid (Rojas *et al.*, 2014). In New Zealand the release of the psyllid parasitoid *Tamarixia triozae* has been recently approved to assist with the biological control of *B. cockerelli* in field crops (EPA, 2016), as well *Amblydromalus limonicus*, a predatory mite for use in greenhouses (EPPO, 2020b).

Phytosanitary risk

Bactericera cockerelli has been found to be a serious and economically important pest in potatoes, tomatoes, and other solanaceous crops in the Western USA, Mexico, Central America and New Zealand, because of its direct feeding impact and as a vector of '*Candidatus* Liberibacter solanacearum' (Guenthner *et al.*, 2012; Munyaneza, 2012). Given the impact of *B. cockerelli* in regions where it occurs, its introduction in the EPPO region would have massive negative impacts, especially if the insects were carrying '*Candidatus* Liberibacter solanacearum'. Suitable host plants are widespread in the region and, given its current distribution in the Americas and New Zealand, it is thought that *B. cockerelli* would be able to establish and overwinter outdoors in the Southern and Central European part of EPPO region, as well as in areas with mild winters in the Northern part of the region, comparable to those of the South Island in New Zealand. It could also establish under protected conditions in the entire EPPO region. Moreover, the migratory behaviour of *B. cockerelli* which favours rapid and long-distance dispersal would put the EPPO region at a high risk, if the psyllid was introduced.

PHYTOSANITARY MEASURES

Suggested phytosanitary measures are specified in the PRA performed by EPPO (EPPO, 2012); they are as follows. All commodities should be accompanied by a Phytosanitary Certificate (PC) and if appropriate a PC of re-export. Fruits of Solanaceae should originate from an area free from *B. cockerelli* or from a pest-free site under complete physical isolation. For tomato only, a Systems Approach is also possible and should include that the fruits are grown under protected conditions, green parts are removed, fruits are washed and fumigated, and consignment inspected. Import of plants for planting of Solanaceae (including potatoes) is prohibited in many EPPO countries. However, if import is considered, the following measures should be considered. Plants for planting of Solanaceae (except seeds) and living parts of Solanaceae (e.g. cut flowers) should originate from an area free from the pest and from '*Ca*. L. solanacearum'. Seed potato (including microplants and minitubers) should originate from an area free from '*Ca*. L. solanacearum' in Solanaceae and ware potatoes should originate from an area free from the pest and '*Ca*. L. solanacearum' in Solanaceae in production. Alternatively, high grade seed potato may be imported under post-entry quarantine, and ware potatoes may be imported for industrial processing purposes. Plants for planting of non-Solanaceous hosts of *B. cockerelli* (e.g. *Micromeria chamissonis*, *Mentha* spp., *Nepeta* spp. and *Ipomoea batatas*) should originate from an area free from the pest and from '*Ca*. L. solanacearum'.

In the event of an outbreak of *B. cockerelli* (with or without haplotypes A or B of '*Ca*. L. solanacearum') in an EPPO country, appropriate eradication measures by delimiting the infested area and defining buffer areas around outbreaks are recommended (EPPO, 2020b).

In 2011, before the arrival of *B. cockerelli* on their territory, the Australian authorities (Plant Health Australia) had

already developed a management plan based on the application of some insecticides capable of protecting potato crops in the different stages of their development (EPPO, 2020). This plan was subsequently adopted in 2018 when *B. cockerelli* was found and deemed no longer eradicable (IPPC website, 2020). EPPO countries can prepare a contingency plan for *B. cockerelli* (EPPO, 2020b).

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ACKNOWLEDGEMENTS

This datasheet was initially prepared in 2013 by J. E. Munyaneza (USDA-ARS, Wapato, US) and extensively

revised in 2020 by Riccardo Bugiani & Massimo Bariselli. Their valuable contribution is gratefully acknowledged.

How to cite this datasheet?

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

Datasheet history

This datasheet was first published in the EPPO Bulletin in 2013 and revised in 2020, it is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', ‘Hosts’, and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

EPPO (2013) *Bactericera cokerelli*. Datasheets on pests recommended for regulation. *EPPO Bulletin* **43**(1), 202-208. https://doi.org/10.1111/epp.12044

Co-funded by the
European Union