EPPO Datasheet: *Gymnandrosoma aurantianum*

Last updated: 2022-08-30

IDENTITY

Preferred name: *Gymnandrosoma aurantianum*
Authority: Lima
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Lepidoptera: Tortricidae
Other scientific names: *Argyroploce torticornis* Meyrick, *Ecdytolopha aurantiana* (Lima), *Ecdytolopha aurantianum* (Lima), *Ecdytolopha torticornis* (Meyrick)
Common names: citrus fruit borer, macadamia nut borer
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EPPO Categorization: A1 list, Alert list (formerly)
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EPPO Code: ECDYAU

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Notes on taxonomy and nomenclature

In addition to the name *Gymnandrosoma aurantianum*, the synonyms *Ecdytolopha aurantianum* and *E. torticornis* are widely used in the literature (EPPO, 2020). Morphological and host differences were observed between the specimens in Costa Rica (*E. torticornis*) and *G. aurantianum* in other parts of its range. For example, the pest has only been reported infesting macadamia in Costa Rica, despite the fact that other known hosts are present in areas where the pest occurs (Blanco-Metzler, 1994; Blanco-Metzler, pers. comm. 2019). It is not known if these differences are biological and ecological or relate to the existence of a complex of species (EPPO, 2020). To date (2021–11), *E. torticornis* is treated as a synonym of *G. aurantianum*, as formalized in Adamski and Brown (2001).

HOSTS

Gymnandrosoma aurantianum has been recorded on a wide range of woody or herbaceous fruit plants, cultivated or in the wild, from various families. Many *Citrus* species are confirmed hosts. When impact is mentioned in the recent literature, it relates mainly to orange (*Citrus sinensis*), mandarin (*Citrus reticulata*), macadamia (*Macadamia integrifolia*), cocoa (*Theobroma cacao*) and sacha inchi (*Plukenetia volubilis*). It is worth noting that some hosts are only recorded in older literature and do not appear in recent literature on outbreaks (EPPO, 2020).

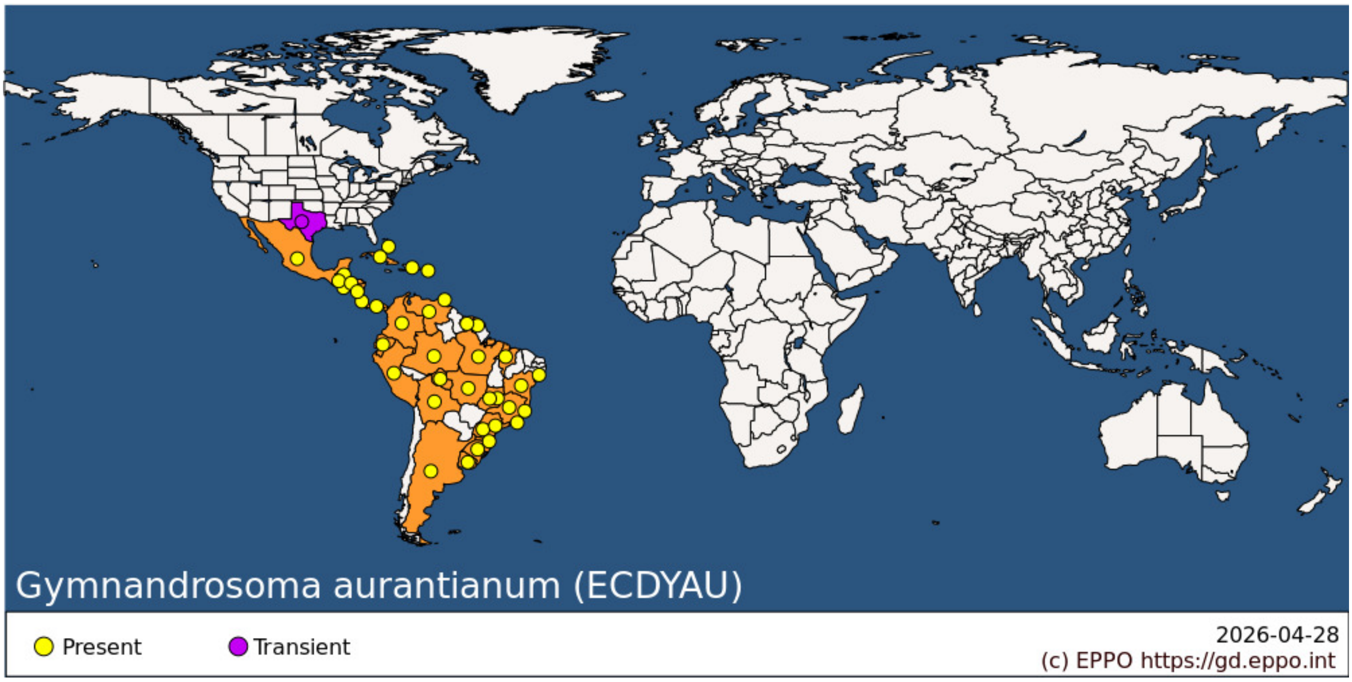
Several authors make the hypothesis that *G. aurantianum* has passed from native hosts to exotic cultivated hosts, such as macadamia in Costa Rica (Blanco-Metzler, 1994). Owing to the wide host range of *G. aurantianum* and the fact that it has passed on to new hosts in the Americas, it is not excluded that it may be able to attack other fruit plants if the fruit is suitable for its development, including *Citrus* species that are currently not recorded as hosts (EPPO, 2020).

Host list: *Annona cherimola*, *Annona squamosa*, *Averrhoa carambola*, *Byrsonima crassifolia*, *Carya illinoinensis*, *Citrus reticulata*, *Citrus x aurantiifolia*, *Citrus x aurantium var. paradisi*, *Citrus x aurantium var. sinensis*, *Citrus x limon*, *Citrus*, *Cojoba arborea*, *Cupania vernalis*, *Eriobotrya japonica*, *Litchi chinensis*, *Macadamia integrifolia*, *Mangifera indica*, *Melicoccus bijugatus*, *Persea americana*, *Pithecellobium dulce*, *Plukenetia volubilis*, *Prunus persica*, *Psidium guajava*, *Punica granatum*, *Sapindus saponaria*, *Theobroma cacao*

GEOGRAPHICAL DISTRIBUTION

G. aurantianum has been recorded in most countries of Central and South America, as well as in Mexico and in a few countries of the Caribbean. As of 2021, its distribution extends between latitudes from ca. 19°N to 34°S (i.e. northern Argentina in the South). The current distribution and pest status of *G. aurantianum* is not known for a number of countries as for these cases little information has been published or records date from the start of the

1900s (including Bolivia, Cuba, French Guiana, Honduras, Mexico, Nicaragua, Panama and Suriname; EPPO, 2020)



North America: Mexico, United States of America (Texas)
Central America and Caribbean: Bahamas, Belize, Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Puerto Rico, Trinidad and Tobago
South America: Argentina, Bolivia, Brazil (Alagoas, Amazonas, Bahia, Distrito Federal, Espirito Santo, Goias, Maranhao, Mato Grosso, Minas Gerais, Para, Parana, Rio de Janeiro, Rio Grande do Sul, Rondonia, Santa Catarina, Sao Paulo), Colombia, Ecuador, French Guiana, Peru, Suriname, Uruguay, Venezuela

BIOLOGY

The duration of the life cycle reported in the literature ranges from 27 to 96 days, and it varies with the attacked host and variety, fruit maturity, temperature and relative humidity (Bento *et al.*, 2004; Fundecitrus, 2007; Parra *et al.*, 2004; White, 1999 citing Parra *et al.*, 2001). In Brazil, *G. aurantianum* has seven to eight generations per year in different regions (Fundecitrus, 2007). In experiments on macadamia in the laboratory, the life cycle lasted 36 days at 23°C and 80% relative humidity, and it was noted that there may be up to 10 generations per year in favorable environmental conditions (Blanco-Metzler *et al.*, 1993). On P. volubilis, the average life cycle took 73 days (Leandro, 2012). In part of its range, where fruit of suitable development stages are available year round and the climatic conditions are favourable, *G. aurantianum* is present in the crops year round, for example in Citrusgrowing regions of Brazil (Parra *et al.*, 2004), in macadamia crops in Guatemala (Primo Miranda, 2003 citing Reyna, 1992) and in *P. volubilis* crops in Peru (Leandro, 2012).

Adults are mostly active at dusk and at dawn (BlancoMetzler, 1994; Bento *et al.*, 2001; Parra *et al.*, 2004; Leandro, 2012). Mating and egg-laying occur a few days after emergence. In laboratory experiments on Citrus, an average pre-oviposition period of 2–3 days was observed and egg laying lasted for 11 days on average (Parra *et al.*, 2004 citing Garcia, 1998). The reported fecundity of females varies widely, from 2–74 eggs per female in experiments on macadamia (Blanco-Metzler *et al.*, 1993) to 140–200 eggs per female in experiments on artificial diet (Garcia & Parra, 1999).

Eggs are normally oviposited on the surface of the fruit (Blanco-Metzler, 1994; Parra *et al.*, 2004; Leandro, 2012). On *Citrus*, females usually lay only one egg per fruit (Vianna, 2015; Arthur *et al.*, 2016). At low pest population levels, ripe fruits are preferred, while different maturation stages including green fruit may be attacked at high population levels (Parra *et al.*, 2004). Green fruits may also be attacked in early infestations (Fundecitrus, 2007). On macadamia, eggs are laid individually on the surface of nuts and females prefer immature nuts (with soft shells). The majority of infested nuts have one or two eggs laid on them, but up to eight eggs per nut have been recorded. Larvae are mostly found singly, but when the pest is abundant, it is possible to find up to three or four larvae in a nut, usually at different instar stages (Blanco-Metzler, 1994). On *P. volubilis*, there was only one larva per fruit in 75% of infested fruit, and two or three larvae in the remaining 25% (Leandro, 2012). Finally, on *T. cacao*, the pest mainly attacks fruits when they start changing colour to ripe fruit, but green fruits are also attacked; there may be over 20 entry holes per fruit (Nakayama, 2018).

Following hatching, larvae enter the fruit within a few hours (Parra *et al.*, 2004 citing Carvalho, 2003). On *Citrus*, within 2–3 days of entry, excrement appears on the rind of the fruit at the entrance hole (Vianna, 2015). On macadamia, larvae feed mainly on the husk, but if the shell has not hardened they tunnel into the kernel (Blanco-Metzler, 1994). In most hosts, larvae remain in the fruit they first enter, but on *Byrsonima crassifolia* they are reported to move to nearby fruit (Gomez Orellana *et al*., 2008), probably because there are insufficient resources in one fruit (small fruit with little flesh; EPPO, 2020).

In *Citrus* crops, pupation occurs mostly in the soil at the base of the plant, and occasionally in other places such as in the fruit (White & Tuck, 1993; Parra *et al*., 2004; Fundecitrus, 2007). Larvae produce a thread on which they descend to the ground (Fundecitrus, 2007). In laboratory experiments, *G. aurantianum* was found to pupate between 0 and 1.5 cm depth, in both humid and dry substrates (Bento, 2008). On macadamia, pupae are mostly found in the nuts or in a cocoon spun by larvae between several nuts in a cluster (Blanco-Metzler *et al.*, 1993; Blanco-Metzler, 1994).

An average temperature of 30°C is reported as being the most suitable for *G. aurantianum* development in Brazil (Fundecitrus, 2007). Viability experiments conducted at 18–32°C are summarized in Parra (2016, based on Garcia, 1998), and male abundance at different temperatures in Reis Jr. *et al.* (2005). A relative humidity of 30–50% decreases the longevity and oviposition capacity of adults (Gómez Torres, 2005 citing Garcia 1998; Leite *et al.*, 2005). In dry seasons, there may be a high abundance of adults (i.e. males trapped) but no damage observed on fruit because the oviposition capacity is reduced at relative humidities below 50% (Fundecitrus, 2019).

DETECTION AND IDENTIFICATION

Signs and symptoms

Signs and symptoms of infestation are on fruit. At early stages of infestation, symptoms are not readily visible externally. In particular, eggs are small and there is often only one egg per fruit. The entry hole is also minute (ca. 1.5 mm on *Melicoccus bijugatus*; Cabrera-Asencio *et al*., 2013). Symptoms become visible at later stages of infestation. On *Citrus*, infestation may cause abnormal coloration, necrotic or bleached areas at the entry hole and fruit fall (White & Tuck, 1993; Fundecitrus, 2007). Discoloration of fruit and rot are reported in several hosts such as *P. volubilis, M. bijugatus* and *T. cacao* (Leandro, 2012; Cabrera-Asencio *et al*., 2013; Nakayama, 2018). Frass may be seen extruding from the hole and sticking to the fruit surface (Fundecitrus, 2007, 2019). On macadamia, the entry hole may be enlarged and frass may emerge from the entry hole. If pupae are in the nuts, close to adult emergence, one-third of their body protrudes from the nut (Blanco-Metzler, 1994).

Morphology

Egg

Eggs of *G. aurantianum* are ca. 1.2 mm long, flattened and circular to ovoid in shape, pale white, darkening to reddish-brown as development occurs (Blanco-Metzler, 1994).

Larva

Larvae of *G. aurantianum* are eruciform, 5 mm long (newly hatched larvae) to ca. 15–19 mm long (mature larvae). The body is pale yellow and the head pale yellow to pale orange with a red-brown patch (Adamski & Brown, 2001; Yamamoto *et al.*, 2006 citing Prates & Pinto, 1988, 1991). There are four to five larval instars (Blanco-Metzler, 1994; Gómez Torres, 2005 citing Garcia, 1998). Larvae of *Gymnandrosoma* can be distinguished from those of *Ecdytolopha* by the distance between various setae (details in Gilligan & Epstein, 2014). A setal map is given in Adamski and Brown (2001). A key to *Ecdytolopha* and *Gymnandrosoma* larvae and a description of last instar larvae of *G. aurantianum* are provided in Adamski and Brown (2001). Brown (2011) provides an online interactive tool to determine if a larvae is a Tortricidae and its possible identity (based on species intercepted in the USA) depending on the host fruit and its geographical origin (http://idtools.org/id/leps/tortai/keys/TortAILarv ae.html).

Pupae

Pupae are fusiform, 9–12 mm long and 2.5–3 mm wide, rounded at both extremities (Adamski & Brown, 2001). Pupae are first pale yellow, becoming brown (Blanco-Metzler, 1994). Pupae of different species of *Gymnandrosoma* cannot be distinguished (Adamski & Brown, 2001).

Adults

Adults are ca. 10 mm long (Gomez Orellana *et al*., 2008) with a wingspan of ca. 11–18 mm (White & Tuck, 1993; Molet *et al*., 2018). They are brown with indistinct reddish-brown and black markings. Most individuals have a conspicuous white dot on the distal one-third of the forewing (Gilligan & Epstein, 2014). Males can be distinguished from other species of *Gymnandrosoma* through external characteristics (on antenna and tibia), while females need to be dissected (Gilligan & Epstein, 2014). A key to *Ecdytolopha* and *Gymnandrosoma* adults and a description of adults of *G. aurantianum* are provided in Adamski and Brown (2001). Illustrated nomenclature of adult genitalia can be found in Adamski and Brown (2001) and Gilligan and Epstein (2014).

Detection and inspection methods

The sex pheromone of *G. aurantianum* has been identified and pheromone traps have been commercially available in Brazil since 2002 (Leal *et al*., 2001; Bento *et al.*, 2016). Details on monitoring using pheromone traps are provided in the EPPO pest risk analysis (EPPO, 2020). The presence of adults is otherwise not easy to detect visually in the field (small size, remain inactive on the plant during the day, mimetic on branches; Blanco-Metzler, 1994; Parra *et al.*, 2004).

Symptoms on fruit are difficult to detect at early stages of infestation and low levels of infestation (USDA, 2003). On *Citrus* and other fruit, frass extruding from the entry hole is a good indicator of the presence of the pest (Batista Pereira, 2008; Vianna, 2015). *G. aurantianum* has been detected in consignments of fruit in trade and in fruits carried by passengers. Symptoms on *Citrus* fruits are quite similar to those of fruit flies; however, the main difference is that the frass of *G. aurantianum* hardens in the rind, while the site of damage by fruit flies is soft and rotted (Fundecitrus, 2007, 2019).

Gymnandrosoma aurantianum can be identified based on the morphology of adults and larvae (Adamski & Brown, 2001) and taxonomic expertise on the family Tortricidae is needed to confirm identification (Gilligan & Epstein, 2014). The pest is very similar to other species in *Ecdytolopha* and *Gymnandrosoma*, and there have been cases of misidentification with other *Gymnandrosoma* species or other Tortricidae (Adamski & Brown, 2001).

Regarding molecular identification, barcodes are available for several specimens from various countries (http://v4.boldsystems.org/). There are also sequences from several specimens of other *Ecdytolopha* and *Gymnandrosoma* species in GenBank. However, it is not clear if the data available would be sufficient for a reliable molecular identification.

PATHWAYS FOR MOVEMENT

Citrus fruit, is the most likely pathway for spread of *G. aurantianum* either in trade or in passenger luggage. *G. aurantianum* is known to be mostly associated with crops of *Citrus*, macadamia and *T. cacao* depending on the origin of the fruit. However, it has been intercepted in a wider range of fruit, such as *Psidium guajava*, *B. crassifolia*, *Punica granatum* and *M. bijugatus* (for exhaustive lists, see EPPO, 2020). In trade, packaging associated with fruit may carry pupae if larvae pupate during transport or storage. It is worth noting that association with nuts of the major host macadamia is very unlikely in trade, because macadamia nuts are normally commercialized after processing, and trading macadamia nuts fresh with husks is not a known practice (EPPO, 2020).

Traded host fruit are imported for consumption or processing, and transfer to a host is generally unlikely, because the pest will be destroyed during processing or damaged fruit will be identified and discarded by processors, retailers or the final consumer in enclosed conditions. However, the pest may be able to transfer to a suitable host where fruit waste from processing or damaged fruit from repacking is discarded in large quantities in the open, close to orchards. This may happen where imported fruit is stored or repacked close to production facilities. Although fruit carried by passengers may contain larvae, transfer to a host would be difficult (EPPO, 2020).

The EPPO PRA assessed the likelihood of entry to the EPPO region on host plants for planting as low. Eggs and larvae may be present on the plant only if there are fruit, which is unlikely for young plants traded internationally, and pupae may be present in the soil or growing medium only if the plant had already borne fruit. Any phytosanitary requirements commonly made regarding dormancy, sanitation or replacement of soil or growing medium associated with plants, and the absence of fruit, would lower the likelihood of association of *G. aurantianum.* Nevertheless, plants for planting may contribute to spread within the EPPO region once introduced, as they may not be subject to similar requirements and, if a nursery producing plants for planting with fruit was infested, there may be many larvae in fruit, or pupae in the soil or growing medium. There are no detailed data on the dispersal capacity of adults, but *G. aurantianum* is reported to be a poor flier with limited flight activity (Batista Pereira, 2008; Blanco-Metzler, 1994 citing Chamberlain, 1989). If the pest is introduced in the EPPO region, flight may contribute to local spread from orchard to orchard. In part of the EPPO region (especially the Mediterranean area), there is a widespread presence of host fruit trees such as *Citrus*, peach and tropical hosts, which could facilitate such spread.

PEST SIGNIFICANCE

Economic impact

Direct damage is caused by larvae feeding in the fruit (*Citrus*, Fundecitrus, 2007; White & Tuck, 1993; *P. volubilis*, Leandro, 2012; *M. bijugatus*, Cabrera-Asencio *et al.*, 2013). Larvae may also reach the seeds (*Citrus*, White & Tuck, 1993; *P. volubilis*, Leandro, 2012; macadamia, Blanco-Metzler, 1994; *T. cacao*, Nakayama, 2018). Indirect damage is due to secondary infestation of larval galleries by other organisms, such as fungi, bacteria, beetles, fruit flies (*Citrus*, White & Tuck, 1993; Gilligan & Epstein, 2014; *B. crassifolia*, Gomez Orellana *et al*., 2008; macadamia, Primo Miranda, 2003), which cause the fruit or nut to rot or fall prematurely (BlancoMetzler *et al*., 2007; Fundecitrus, 2007; Cabrera-Asencio *et al*., 2013). The type of damage is not documented for all hosts, but is probably similar (damage to fruit flesh and seeds, fruit rot, secondary infestation by other organisms, possibly premature fall). Economic impact of *G. aurantianum* on fruit production has been reported in Central and South America. For most hosts, once larvae have entered the fruit, it becomes unsuitable for consumption, commercialization and processing (Citrus, Bento *et al.*, 2001; Parra *et al.*, 2004; *M. bijugatus*, Cabrera-Asencio *et al* ., 2013). However, superficial damage does not prevent the use of macadamia fruit (Blanco-Metzler, 1994) or seeds of *T. cacao* (Nakayama, 2018). The occurrence of the pest can also have consequences for export (Garcia & Parra, 1999). *G. aurantianum* is a quarantine pest for several countries, with phytosanitary requirements mostly relating to *Citrus* or macadamia.

Economic impact on *Citrus* production is well documented from Brazil. *G. aurantianum* was first observed causing damage in São Paulo State in 1915 (Bento *et al*., 2001 citing Lima, 1927). It remained a minor pest until the end of the 1980s (Parra *et al.*, 2004) and then became a limiting factor to *Citrus* production. In São Paulo State, damage was estimated at 50 million USD per year during the 1990s and yield losses up to 50% were reported (Anonymous, 2016; Bento *et al*., 2001 citing Garcia *et al.*, 1998). Following the implementation of a new IPM strategy based on pheromone traps, losses were reduced by on average to 0.6–1 fruit per *Citrus* plant in São Paulo and Minas Gerais (Bento *et al.*, 2001, 2004 citing Carvalho, 2003). *G. aurantianum* has also been reported as a pest on *Citrus* in Ecuador (Noboa *et al*., 2018), and there are older records of severe infestations in Argentina at the end of the 1930s (Lima, 1945), and at the beginning of the 1990s in Trinidad (White, 1999). In Uruguay, *G. aurantianum* is mentioned as being occasional and not of potential economic importance (COSAVE-IICA, 1999), with infestations limited to isolated *Citrus* fruits in domestic groves (USDA, 2012 citing Bentancourt and Scatoni, 2006).

On macadamia, damage from *G. aurantianum* (then known as *E. torticornis*) in Costa Rica was first observed in 1986 and maximum nut damage progressively increased to reach ca. 40% (Blanco-Metzler, 1994 citing Lara 1987; Blanco-Metzler *et al*., 2007 citing Blanco-Metzler *et al*., 1992). Management strategies have reduced the impact of the pest below its economic damage threshold (H. Blanco-Metzler, pers. comm., 2019). Damage on macadamia was also reported in Guatemala (Primo Miranda, 2003), Colombia (García, 2005), Venezuela (Briceño & Sharkey, 2000 citing Arizaleta *et al.*, 1997) and recently in Brazil (Soares de Matos *et al.*, 2019).

On *Theobroma cacao, G. aurantianum* has been reported as a pest in Venezuela (Delgado Puchi, 2005), Colombia (Muñoz *et al.,* 2018) and recently Brazil (Nakayama, 2018). Economic impact has also been reported on *P. volubilis* in Peru (Leandro, 2012). Information on impact is not available from many countries where the pest occurs, and for many hosts. It is possible that in some countries *G. aurantianum* is not present in commercial fruit production, and only attacks native hosts or fruit hosts in other situations (native environment, gardens, parks, urban areas, etc.).

Control

Control methods are well documented for Citrus crops in Brazil. In the 1980s, control relied on the application of pesticides when attacked fruits were observed, which did not control the pest and eliminated natural enemies, thereby increasing losses (Parra *et al*., 2004). At the beginning of the 2000s, the sex pheromone was identified, and an alternative strategy was developed, based on the application of microbial or chemical sprays when a threshold of males in pheromone traps is reached (Parra *et al.*, 2004). The total volume of insecticides sprayed in the monitored areas decreased by at least 50% (Parra *et al.,* 2004). Parasitoids and predators of *G. aurantianum* are documented (Briceño & Sharkey, 2000; Gómez Torres, 2005; Leite *et al*., 2005; Batista Pereira, 2008; Blanco-Metzler *et al*., 2009) and natural enemies have a role in controlling the pest in the field. However, natural enemies are apparently not being actively released in the framework of biological control strategies. Cultural control is used on *Citrus* in Brazil in addition to chemical control, and is effective on its own in macadamia crops in Costa Rica.

Cultural measures include collecting and destroying infested fruit on the ground and on trees (Fundecitrus, 2019), early harvest in case of attack to avoid the build-up of populations (Fundecitrus, 2007, 2019) and avoiding planting fruit-bearing hosts within a radius of 400 m of *Citrus* crops (Batista Pereira, 2008). In macadamia crops, control relies on monitoring, replacement of susceptible clones and more frequent harvest to avoid completion of the life cycle. Finally, macadamia husks are traditionally disposed of on the ground in the orchards after nut processing, but this favours infestations and should be avoided (Blanco-Metzler *et al.*, 1997).

Phytosanitary risk

Citrus is a main host of *G. aurantianum* and has a high economic importance in the EPPO region. The EPPO PRA determined that *G. aurantianum* may pose a risk in areas where host fruits are present all year round, where climatic conditions are suitable and *Citrus* is grown (i.e. on the Mediterranean coast, southern Portugal and the Atlantic coast of Morocco, as well as part of northern Italy, the Balkans and the Black sea area) (EPPO, 2020). In such areas, economic impact in *Citrus* crops may be initially as high as that seen in Brazil, depending on how early the pest is detected, but an IPM programme using pheromone traps could be developed based on that in Brazil. Many hosts, such as *Punica granatum* and to a lesser extent tropical fruit hosts (such as *Annona cherimola, Averrhoa carambola, Macadamia integrifolia* and *Psidium guajava*), are present in the EPPO region, which may increase economic impact and integrated strategies may need to be adapted. *G. aurantianum* has attacked new hosts in the Americas, and may also pass on to new hosts in the EPPO region. Finally, the presence of this pest in the EPPO region may affect export markets (EPPO, 2020).

PHYTOSANITARY MEASURES

The EPPO PRA (EPPO, 2020) recommended phytosanitary measures for *Citrus* fruit, with options such as pestfree area, pest-free place of production and pest-free production site. In addition, a systems approach was recommended, combining visual inspection in the field (with cutting of representative samples of fallen fruit), treatment of the crop based on monitoring with pheromone traps, visual examination at harvest and during handling/ packing of the consignment and visual inspection at export (with cutting of representative samples of fruit). In addition, only new or cleaned packaging should be used to avoid the presence of pupae. Such measures can also be considered for other host fruit if necessary. It is worth noting that no treatment can currently be recommended for *Citrus* fruit or other host fruit. In particular, no cold treatment schedule is available against this pest. As for many fruit pests, the separation of fruit imports and production is important (see Pathways for movement). Measures such as awareness and checks may be applied to travellers' luggage to prevent entry with fruit, and to a lesser extent with plants for planting. The pest is less likely to enter on host plants for planting in trade and measures were not recommended.

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