Preparedness in biological control of priority biosecurity threats

Oriental fruit fly, *Bactrocera dorsalis* (Hendel)

Introduction

Bactrocera dorsalis (Hendel) (Diptera: Tephritidae), commonly known as Oriental fruit fly, is a highly polyphagous invasive pest that can cause serious economic damage to a wide variety of fruit and vegetable crops. Originating from tropical areas of South East Asia, it has invaded at least 50 countries, including parts of America, Oceania, Asia and most of continental Africa. Crop damage is caused through punctuation by oviposition under the fruit skin and the subsequent larval development. *B. dorsalis* has a broad host range with over 270 types of fruits and vegetables species recorded as hosts. International tourism and trade of infested fruit are the main causes of introduction of *B. dorsalis* into new areas, where it has a high dispersal ability based on extreme polyphagy on fruit crops, high reproduction rates and good mobility. Therefore, *B. dorsalis* ranks high on worldwide quarantine lists (Loomans et al. 2019; Vargas et al. 2015).

The potential dispersion is mainly limited due to the climatic range of *B. dorsalis* to tropical and subtropical areas. The chances of establishment in warm temperate areas such as southern Mediterranean Europe and northern New Zealand are low. However, under irrigation or with the climate change these areas potentially become more suitable (Villiers et al. 2016).

History of classical biological control against *Bactrocera dorsalis*

Fopius arisanus (Sonan) and *Diachasmimorpha longicaudata* (Ashmead) (Hymenoptera: Braconidae) were successfully introduced in Hawaii in the late 1940s against *B. dorsalis.* In a one-year assessment period, *F. arisanus* achieved parasitism rates up to nearly 60% in *Psidium cattleianum* and *Psidium guajava*. In contrast, *D. longicaudata* parasitism rates remained under 2.5%. Since the establishment of *F. arisanus* in Hawaii, a dramatic reduction in fruit infestation has been recorded through a high level of parasitism (65–70%) on *B. dorsalis*, where it has remained the dominant parasitoid species (Vargas et al. 2012a).

In 2002, *F. arisanus* was introduced into French Polynesia as part of a classical biocontrol programme against *B. dorsalis*, resulting in a reduction of the pest populations, with reported parasitism rates up to 65%. In 2007, *D. longicaudata* was introduced from Hawaii into French Polynesia as an additional biocontrol agent against *B. dorsalis*. However, it has not been as effective as *F. arisanus*, with parasitism rates not higher than 10%. The establishment of *F. arisanus* in French Polynesia is currently regarded as the most successful example of classical biological control of fruit flies in the Pacific outside of Hawaii (Vargas et al. 2012b)

F. arisanus was also introduced to Africa. In Senegal, preliminary results of inoculative release in mango orchards seem promising with 5 – 6 times more infested fruits in the control orchard compared with orchards where *F. arisanus* was released (Ndiaye et al. 2015). In Benin, a parasitism rate of up to 47% and a reduction of *B. dorsalis* populations by 33 – 65% in bush mangos in a four year study could be shown (Gnanvossou et al. 2016).

F. arisanus was introduced for the control and suppression of tephritids in Australia, Central America and various Pacific Island countries, and in the Mediterranean basin. However, release was not as successful in other regions, like Australia (little effect on Tephritidae) or Florida (USA; Introduction unsuccessful) (Rousse et al. 2005).

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Most promising natural enemies

F. arisanus seems to be the most promising natural enemy for use in classical biological control programmes against *B. dorsalis*. High rates of parasitism and reductions in *B. dorsalis* populations have been achieved using *F. arisanus*; however, it has not established in all attempted areas or has not resulted in expected success (see above). *F. arisanus* originates from southern Asia. Due to the climatic adaption, highest parasitism rates of *B. dorsalis* are reported from a lab study at 25 °C and the lower threshold temperature is predicted as approximately 10 °C, which is similar to that of *B. dorsalis* (Appiah et al. 2013).

F. arisanus is known to parasitize around 40 tephritid species suggesting that the females do not recognize hosts on a species-specific level but rather as part of the Tephritidae family (Rousse et al. 2007).

Several lab studies and monitoring have shown strong competition with or displacement of other parasitic wasps. However, even though *F. arisanus* is the dominant parasitoid a combined approach with other biological control agents (e.g. *Psyttalia incisi (*Silvestri) (Hymenoptera: Braconidae)) could be considered, as it might even increase host mortality. Also, using *F. arisanus*, which is an egg-larval parasitoid, along with other parasitoids that attack other host developmental stages (e.g. *D. longicaudata* which attacks fruit fly larval stages) could be a good synergistic strategy to maximize biocontrol efforts against *B. dorsalis.*

Other natural enemies

There are many hymenopteran species listed as capable of parasitizing *B. dorsalis* (CABI, 2022). However, often they achieve much lower parasitism rates than *F. arisanus* and in a combined release with *F. arisanus* their effectiveness is likely to be reduced by competition.

B. dorsalis is also predated upon by ants. *Oecophylla longinoda* (Latreille) (Hymenoptera: Formicidae) is an arboreal weaver ant occurring in humid-tropic Africa, limited in dispersal by temperature, humidity and suitable evergreen trees. Van Mele et al. (2007) demonstrated a reduction of *B. dorsalis* as a result of predation by *O. longinoda* during an augmentative field study in Africa. However, this species of ant is a generalist also attacking other arthropods. As a result, an introduction as a biological control agent might negatively affect local diversity especially as negative interaction effects with parasitoids have been shown. Furthermore, *Oecophylla* species are often considered as pests due to their aggressive behaviour, biting farmers and disrupting farming processes.

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