Crop Protection 60 (2014) 1–4

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Preparing the way for sterile insect release: Determination of false codling moth distribution across a landscape mosaic

R.L. Stotter [a], M.J. Samways [a,*], V. Hattingh [b]

[a] Department of Conservation Ecology and Entomology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa
[b] Citrus Research International, Department of Conservation Ecology and Entomology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa

ARTICLE INFO

Article history:
Received 21 October 2013
Received in revised form
27 January 2014
Accepted 31 January 2014

Keywords:
FCM
Thaumatotibia leucotreta
Sterile male release
Citrus
Moth dispersion patterns
South Africa

ABSTRACT

Sterile insect release (SIR) for control of insect pests focuses on release of sterile individuals within the focal crop. Its success is related to the extent to which pest individuals are concentrated in the crop or spread out across the landscape mosaic. However, little is known of the success of SIR relative to spatial densities of target insect pest populations. This is especially so for the false codling moth (FCM) *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), an indigenous moth to Africa and one of considerable phytosanitary significance. The aim here was to establish densities of the moth across a citrus production landscape in South Africa where the pest is particularly significant. Pheromone-baited delta traps were laid out in transects across a commercially important citrus-producing valley to assess the spatial and temporal distribution of wild males, prior to implementation of a commercial SIR programme. Transects included the focal citrus orchards, while also including a range of natural habitat types and elevation gradients. Male FCM were mostly confined to the citrus orchards, while those outside were close to citrus orchards or in alien alternative host plant patches, with only a few male individuals being caught up to 1.5 km from the nearest orchard. This suggests that the indigenous vegetation is supporting only a low FCM population, while, in contrast, citrus orchards are the main reservoir for FCM populations. These findings emphasize the importance of focussing SIR for FCM within the crop and on other, adjacent alien host plants, and not to dissipate releases into the surrounding and extensive natural vegetation.

1. Introduction

The false codling moth (FCM) (*Thaumatotibia leucotreta* (Meyrick), Lepidoptera: Tortricidae) is an indigenous pest of citrus fruit, and numerous other crops in sub-Saharan Africa (Newton, 1998; Reed, 1974; Schwartz, 1981; Stibick et al., 2007). It is an important phytosanitary insect, impacting negatively on the export of fresh citrus fruit to international markets (Hofmeyr et al., 2005). FCM is known to infest most types of citrus (*Citrus* spp.), with the Navel orange cultivar (*Citrus sinensis* (L.) Osbeck var Navel) being particularly prone to attack, largely due to the presence of a navel end which favours the oviposition of eggs (Schwartz, 1981; Newton, 1990). The efficacy of conventional insecticidal control is being compromised by appearance of insecticide resistance in FCM populations (Hofmeyr and Pringle, 1998), as well as residue restrictions imposed by export markets. Mating disruption, pest-specific granulovirus applications, sterile insect release (SIR) and the integration of the various suppression techniques, including strict orchard sanitation, are options that are currently being adopted (Hofmeyr and Pringle, 1998; Newton, 1998; Moore, 2012).

Little is known about FCM host preferences, or about its dispersal capacity. However, genetic studies suggest that FCM has low dispersal capability (Timm et al., 2010). The movement of FCM between various host types, including citrus orchards, and its ability to maintain a viable population in alternative host plants when there is no fruit available for infestation in citrus orchards has not been well investigated. Knowledge of these largely behavioural facets is important for planning an effective management strategy for FCM, especially SIR, the effectiveness of which would be potentially reduced should there be a substantial population of FCM in natural vegetation outside citrus orchards. In response, the aim of this study was to determine the spatial distribution of FCM at the landscape scale, so as to provide a platform for implementation of an area-wide control strategy that includes the SIR technique.

* Corresponding author. Tel.: +27 21 808 3728; fax: +27 21 808 4807.
E-mail address: samways@sun.ac.za (M.J. Samways).

http://dx.doi.org/10.1016/j.cropro.2014.01.017
0261-2194/

Table 1
Positions of the pheromone-baited delta traps outside of citrus orchards for sampling false codling moth males.

Trap no.	Distance from citrus orchard (m)	Elevation above citrus orchard (m)	Distance-elevation units (Dist × elevation)
1	50–200	≤20	≤4000
2	200–400	20–50	4000–20 000
3	400–600	50–70	20 000–42 000
4	600–900	70–100	42 000–90 000
5	900–1200	100–150	90 000–180 000
6	1200–1500	150–200	180 000–300 000
7	>1500	>200	>300 000

2. Materials and methods

The study was conducted in the Citrusdal area, Western Cape Province, South Africa (S32°35.700′; E18°59.300′). The study area included the agriculturally intensive Olifants river valley, bordered on either side by montane natural fynbos vegetation (mostly *Protea* spp., *Erica* spp. and *Restio* spp.). The valley is ±70 km long, 7–10 km wide. This study site was chosen because of its suitability for the implementation of an SIR programme, being enclosed by mountain ranges and fairly isolated, with citrus on the valley floor and natural fynbos vegetation on either side. It also has high levels of FCM (Marais, 1982) across the >5000 ha of planted citrus.

Six transects were laid out across the valley, which runs roughly in a north-south direction. Each of the six transects was 5–10 km apart, spanning 55 km along the valley. Each transect was ±8 km long, and made up of 21 FCM pheromone-baited traps, with seven of these in citrus orchards across the valley floor from west to east, and seven traps in natural vegetation either side of the valley.

The cultivars were mostly Valencia (*Citrus sinensis* (L.) Osbeck var Velencia) and Navel oranges, with some Clementine (*Citrus reticulate* Blanco) and Satsuma mandarin (*Citrus unshiu* Marcow.). This range of citrus types enabled FCM to be recorded across a broad season, with mandarin fruits present from March–July, Navel fruits May–July, and Valencia fruits August–November. Young citrus fruitlets are susceptible to FCM attack (Newton, 1998) and become available from late November onwards.

In total, nineteen traps were placed in Valencia orange orchards, which are less susceptible to FCM infestation than Navel oranges and consequently fewer FCM control practices are applied in these orchards. Eighteen traps were placed in Navel orchards which are subject to heavier infestation by FCM with consequently more control practices being applied to them. Five traps were placed in orchards consisting of mixed cultivars, including Valencia, Navel and Mandarin.

Traps outside citrus orchards were laid out according to distance-elevation units (distance from orchard × elevation above orchard) (Table 1). This compensated for the slope on either side of the valley being uneven. Traps closest to citrus orchards were placed <200 m from the focal orchard and <20 m in elevation above the orchard floor. Traps farthest away from citrus were placed >1500 m from the citrus, and at an elevation of ±200 m above the nearest orchard. All the other traps were placed at even intervals between these two values.

Moth individuals were sampled with yellow delta traps which capture more individuals than other commercially available traps (Newton and Mastro, 1989). The Lorelei® FCM pheromone dispenser was used in the delta traps. Each dispenser contains 0.1 ml per ampule of (E)-7-dodecenyl acetate/(E)-8-dodecenyl acetate/(Z)-8-dodecenyl acetate and has a constant release rate (Hofmeyr and Burger, 1995). Pheromone dispensers were replaced when the liquid pheromone began to run out, at ±6 month intervals. Within the delta traps, Chempac glue pads were used to entrap the male FCM individuals and these were replaced every second week when dirty, or at least every month.

Traps were hung according to Citrus Research International (CRI) guidelines (Grout et al., 1998). In citrus orchards, traps were positioned ±2 m above ground, in the outer tree canopy, and visible from a 180° angle, and with a free flow of air through the trap. To this end, traps were hung on the windward, southern side of the trees, and orientated north-south. Traps were also on the southern, windward side of the orchard, as male moths fly upwind to find a mate (Carde and Minks, 1995). Each trap was placed in the 5th tree in the 5th row from the perimeter of the windward side of the orchard, and >20 m from any windbreaks.

Outside orchards in natural fynbos vegetation, traps were similarly placed, with the 2 m height trap placement being obtained by placing the traps in wild olive (*Olea europaea* L.) trees or in *Protea* spp. bushes, or any other sizeable plants, including alien oak trees (*Quercus robur* L.). Traps were monitored every second week for 18 months, beginning April 2006 to October 2007, covering two harvest seasons.

3. Results

In the first season (April–November 2006), more FCM male individuals were sampled in mixed-variety citrus orchards, than in

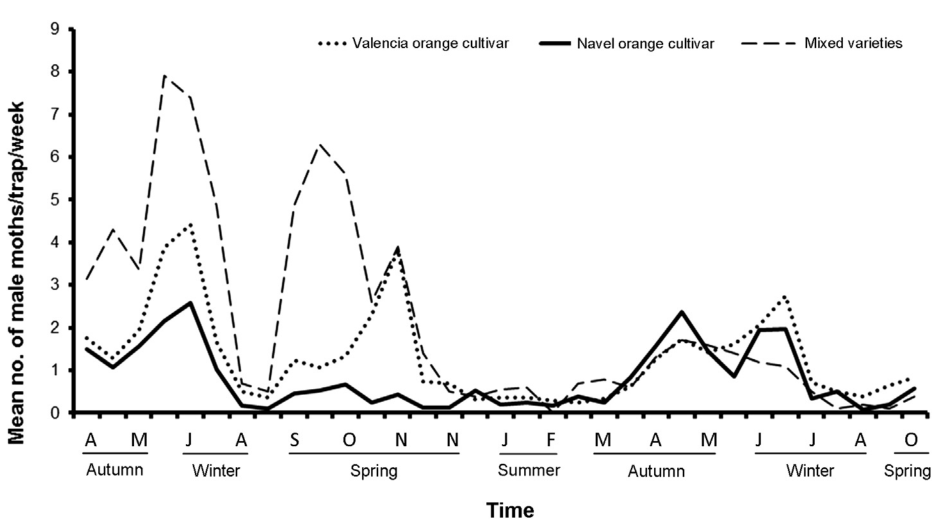

Fig. 1. Trap captures of male false codling moths in pheromone-baited delta traps placed within different varieties of citrus over the whole study period.