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Ceratitis capitata (Diptera: Tephritidae), em S. Miguel-Açores. Eficácia de nemátodes entomopatogénicos contra a mosca da fruta.

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Abstract

The distribution and abundance of *Ceratitis capitata* in peach, guava, feijoa, hot pepper and citrus orchards was analysed in this study, as well as the efficacy of different nematodes isolates to control the medfly last instar larvae and pupae. *C. capitata* was present in all the field crops throughout the sampling period, although the highest number of adults was trapped during summer and autumn. The highest mean number of captured adults was observed in feijoa orchard, followed by hot pepper and citrus crops. Although in the peach orchard the mean number of trapped adults was low, the percentage of fruit infestation was similar (over 60 %) to that of feijoa, citrus and hot pepper fruits; for guava, only 24.9% of the fruits were infested by *C. capitata*. Regardless of the crop, all traps containing the male-attractant pheromone showed to be the most effective to estimate the distribution and abundance of the medfly. Regarding the efficacy of different isolates of nematodes those from the *Heterorhabditis* genera were more effective keeling both the larvae and pupae of *C. capitata*; however, only the isolate Az36 (*H. bacteriophora*) caused a larval mortality significantly higher than the control.

Introduction

Ceratitis capitata (Diptera: Tephritidae), also designated as the Mediterranean fruit fly or medfly, is one of the world's most well-known and damaging pests of fruit crops. It is considered one of the most important fruit pests in the world because it develops in fruit species, most of which are of high commercial value (LIQUIDO et al. 1991). Originated from Africa (WHITE & ELSON-HARRIS 1992), this species extended first to the Mediterranean region during the early 19th century, and from there to the rest of world (HEADRICK & GOEDEN 1996). In 1829, MacLeay refers the presence of *C. capitata* in orange fruits produced in Azores (Portugal) exported to England (PIEDADE-GERREIRO1987). Due to the severe damages caused by *C. capitata* in fruit crops that have an important impact on the Azorean economic agricultural outputs, studies regarding the biology and ecology of this species are being developed. Therefore, with this study we aimed to i) analyse the distribution and abundance of *C. capitata* in the following crops: peach, guava, feijoa, hot pepper and citrus, and ii) evaluate the efficacy of different nematodes, isolated in Azores, to control last instar larvae and pupae of *C. capitata*.

Material and Methods

Distribution and abundance of *C. capitata*

Samples were carried out, from April to December 2004, in six different field crops in S. Miguel Island, Azores-Portugal. Studies were conducted in two crops of hot pepper (*Capsicum annuum*), one located at Ramalho and the other at Abelheira and, each one of the others corresponded to guava (*Psidium cattleianum*), feijoa (*Feijoa sellowiana*), peach (*Prunus persica*) or citrus (*Citrus* spp.) orchards. All the sampled fields were located at an altitude of 58-140m, in the south part of the Island, except for the peach orchard that was situated at northeast part of São Miguel.

Adults populations were monitored with McPhail traps baited with three different attractants: i) a male-specific attractant (Trimedlure, Agrisense); ii) hydrolysed protein (Endomosyl, Agrevo) and, iii) ammonium acetate, putrescine and trimethylamine (Biolure, Biosani). Traps were placed in triangular distribution 10-15 m apart, with one trap of each type per crop. All traps were placed 1.5-1.8m above the ground in the canopy of host trees. The liquid (hydrolysed protein or water) in the lower part of the traps was replaced every week and the Biolure dispensers were replaced every 1.5 month. Male attractant (Trimedlure) was renovated every 3 months. Traps observed weekly and the captured *C. capitata* adults were counted and removed.

To determine fruit infestation, in each crop fruits were collected and immediately brought to the laboratory. The number of fruits collected each week, per crop depended on their size and their production on the trees (see Table 2). In laboratory, each fruit was placed in a plastic container on a 3 cm layer of dry sand, to hold the exudates dripping from the rotting fruits and serve as pupation area for mature larvae as they left the fruits. Fruits were held inside a climatic chamber at 25±2 ºC, with a photoperiod of 14L: 10D, while humidity was kept at 70±5 %. Each day, all fruits were checked to collect and count the emerging mature larvae and pupae by sieving the sand.

Efficacy of the nematodes

Nematodes were reared on last instars larva of *Galleria mellonella* (L.) (Lepidoptera: Pyralidae) according to the methodology used by DUTKY et al. (1964). The following nematodes isolated in Azores (ROSA et al. 2000), were tested: *Steinernema carpocapsae* (isolates Az 143, 149, Az 152, Az 153 and Az 155); and, *Heterorhabditis bacteriophora* (isolates Az 36, Az 39, Az 144 and Az 148). Larvae and pupae of *C. capitata* were reared in laboratory according to the methodology of MEDEIROS (2004).

The efficacy of the nematodes was studied using a methodology adapted from LINDEGREN & VAIL (1986). Bioassays were conducted in plastic cups containing 150 ml of dry sand (48 h at 50 ºC). To homogenise the humidity, 25 ml of distillate water was added to the sand, corresponding to 17% (v/v) of soil moisture. In each cup, 1 ml of a nematode suspension with 1000 IJs was placed in the midpoint of surface of the sand. A control group was performed using sterile water. Twenty four hours later, one 3rd instar larva of *C. capitata* was placed on the sand surface and allowed to borrow into it, or one pupa (<24h) positioned at 2.5 cm of profundity. Each cup was closed with parafilm to maintain

the humidity, replaced by a net of *mousseline* at the end of the first week All tests were done under a natural photoperiod, with a temperature of 21±1ºC. Mortality was recorded 17 days after treatments and dead pupae were dissected to confirm the presence of nematodes.

Data analysis

Proportional data were normalized through arcsine transformation and all the other data were normalized through square root transformation.

The number of captured adults and the mortality of larvae and pupae were compared by an ANOVA, followed by Scheffé tests when significant differences ($P< 0.05$) were observed among data sets or, by *t*-tests. Percentages of fruit infestation were analysed by a Multiple Comparison test for Proportions (ZAR 1996). All analyses were performed using SPSS 10.0 Windows (SPSS INC. 1999).

Results

Ceratitis capitata was present in the fields throughout the sampling period and the number of trapped adults was higher during the warmer seasons (summer and autumn) (Figure 1).

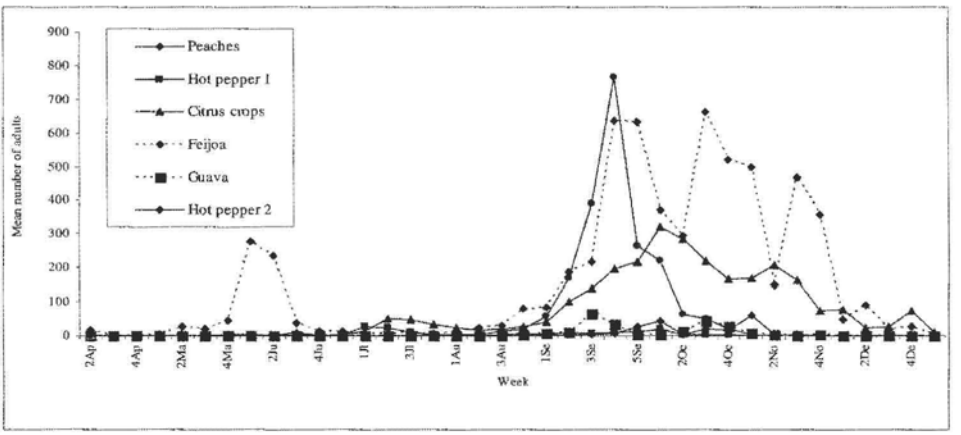

Figure 1 - Number of adults of *C. capitata* captured weekly in each crop using the different baits, from April to December 2004.

The highest mean number of captured adults was observed in feijoa orchard, followed by hot pepper and citrus crops; in guava and peach crops the mean number of adults of *C. capitata* was very low (Table 1).

Regardless of the crop, all traps containing the male-attractant pheromone captured the highest numbers of adults, while those with Biolure attracted more females than hydrolysed protein traps. This

last bait showed to be the less effective, only attracting *C. capitata* adults when their density was very high (Table 1).

Table 1 - Number of *C. capitata* adults (mean ± s.e.) captured by the three different baits in each crop, from April to December 2004.

Local/Crop	Trap type	Males	Females	Total
Ramalho	Trimedlure	3,52±1,18a	0,00±0,00b	3,52±1,18a
Hot pepper 1	Biolure	0,81±0,25b	2,86±0,63a	3,67±0,84a
	Hydrolysed protein*	0,00±0,00*	0,00±0,00*	0,00±0,00*
Abelheira	Trimedlure	94,81±40,59a	0,05±0,05a	94,86±40,63a
Hot pepper 2	Biolure	0,48±0,19b	1,05±0,33a	1,52±0,47b
	Hydrolysed protein*	0,00±0,00*	0,05±0,05*	0,05±0,05*
Nordeste	Trimedlure	4,67±2,20a	0,00±0,00b	4,67±2,20a
Peach	Biolure	0,29±0,17b	0,33±0,16a	0,62±0,29a
	Hydrolysed protein*	0,00±0,00*	0,00±0,00*	0,00±0,00*
Lagoa	Trimedlure	68,62±18,95a	0,00±0,00b	68,00±19,05a
Citrus	Biolure	5,00±1,07b	15,90±6,54a	20,90±7,14b
	Hydrolysed protein*	0,00±0,00*	0,00±0,00*	0,00±0,00*
F. de Cima	Trimedlure	8,33±3,70a	0,00±0,00b	8,33±3,70a
Guava	Biolure	0,10±0,07b	0,19±0,11a	0,29±0,12b
	Hydrolysed protein*	0,00±0,00*	0,05±0,05*	0,05±0,05*
S. Gonçalo	Trimedlure	157,95±41,01a	0,29±0,12b	158,24±41,09a
Feijoa	Biolure	4,81±2,24b	19,14±6,96a	23,95±8,59b
	Hydrolysed protein*	0,71±0,31b	1,14±0,40b	1,86±0,69b

Values, within each sampled crop and in each column, that are followed by a different letter are significantly different ($P<0.05$, *t*-test or Scheffé tests).

All fruit species were infested by *C. capitata*, with observation of individuals at the pupal stage. The percentage of fruit infestation was similar for peach, feijoa, citrus and hot pepper and, significantly higher than guava ($P<0.05$) (Table 2).

Among the different studied nematodes, those from the *H. bacteriophora* genera were the more effective keeling both the larvae and pupae of *C. capitata*. However, only the isolate Az36 caused a larval mortality significantly higher than the control (Table 3).

Table 2 - Percentage of fruit infestation by *C. capitata* in the five sampled fruit species.

Fruit fly host plant species	Number of observed fruits	Fruit infestation (%)
Capsicum annuum	326	61.96a
Citrus sinensis	59	66.10a
Feijoa sellowiana	1027	68.74a
Prunus persica	240	69.17a
Psidium cattleianum	669	24.96b

Values in the column that are followed by a different letter are significantly different ($P<0.05$, Multiple Comparison test for Proportions).

Table 3 - Mortality (%) of C. capitata larvae and pupae when treated with different isolates of *H. bacteriophora* or *S. carpocapsae*.

	Isolate	N	Larva	N	Pupa
H. bacteriophora	Az36	40	47,50b	40	35,00a
	Az39	40	35,00ab	40	52,50a
	Az144	40	37,50ab	40	32,50a
	Az148	40	37,50ab	40	37,50a
S. carpocapsae	Az143	40	2,50a	40	40,00a
	Az149	39	23,08ab	40	35,00a
	Az152	40	5,00a	40	52,50a
	Az153	39	20,51ab	40	45,00a
	Az155	40	25,00ab	40	35,00a
	Az157	40	27,50ab	40	47,50a

Values in the column that are followed by a different letter are significantly different ($P<0.05$, Scheffé tests).

Discussion

Data showed that *C. capitata* is present in the crops during all the period of sampling, most of them with high percentages of fruit infestation, particularly in the crops with ripening periods comprised between August and November; therefore, this specie can be considered an important pest in São Miguel Island. ROS et al. (1999) and PAPADOPOULOS et al. (2001) also refer that the medfly is particularly abundant during the warmer seasons in Spain and north of Greece, respectively. The high percentage of fruit infestation in hot pepper, particularly when lately harvested, indicates that *C. capitata* can cause severe damages in this crop, with a negative economic impact in the Azorean agriculture.

Among the different tested baits, Trimedlure showed to be the most effective for the capture of *C. capitata* adults, thus it must be used wherever information regarding the distribution and abundance of the medfly is required, as observed in other studies (BORGE & BASEDO 1997; ROS 1997;

KATSOYANNOS et al. 1999). On the other hand, Biolure should be used to control *C. capitata* populations, since it captured more females than hydrolysed protein. HEATH et al. (1997) and BROUGHTON & LIMA (2002), compared the efficacy of several baits, and concluded also that Biolure was the most effective to capture *C. capitata* females.

In what concerns the efficacy of the different nematodes, data showed that *H. bacteriophora* AZ36 isolate can be a potential agent for the control *C. capitata*; however further studies are required to improve the efficacy of this nematode, namely soil moisture and density.

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