**Field selectivity of a spinosad-poisoned bait toward target tephritids and non-target insects**

**Abstract:** The paper evaluates field selectivity of a spinosad-poisoned bait, the so-called GF-120 bait, in a 20-year-old olive orchard, where 12 baited and 12 unbaited traps were positioned for insect monitoring. The abundance of the most common orders of insects and target pest species was assessed. The main finding of this research is that many pollinators are not attracted by the bait, while target and non-target tephritids are significantly attracted by the bait with the exception of Muscidae. The attraction toward a part of non-target Diptera was not assessed. A field test is needed to evaluate the impact of this bait on pest species and the wild populations of non-target organisms. The need of pest control strategies safer for the environment and the wild populations of non-target species seems to be satisfied by the use of this bait.

**Key words:** Bactrocera oleae, Ceratitis capitata, GF-120, Sustainable agriculture.
olfactory and alimentary attractants in conjunction with pheromones in order to control both sexes. Different kinds of insecticides acting by contact, such as deltamethrin and lambda-cyhalothrin, or by ingestion, such as spinosad, are utilised. Poisoned baits seem to be safer for parasitoids of target pests (Stark et al., 2004), but the efficacy on target pests and impact on non-target insects strongly depends on their selective attractiveness.

The efficacy of spinosad-based insecticides has been confirmed against several pests. Spinosad is a mixture of spinosyns A and D produced by the Actinomycetes Saccharopolyspora spinosa (Mertz & Yao, 1990) altering nicotinic and gamma-aminobutyric acid receptors functions acting mainly by ingestion. A spinosad-poisoned sugar-based bait, GF-120 bait, recently appeared on the market, is mainly utilised against tephritid fruit flies (Diptera: Tephritidae) Ceratitis capitata (Wiedemann, 1824) in citrus orchards and Bactrocera oleae (Rossi, 1790) in olive groves. It is applied only in a spot of droplets on the tree canopy.

The toxicity of spinosad for non-target insects is demonstrated by several authors (Mayes et al., 2003; Miles, 2003, 2006), depending on the concentration of the active ingredient. However, the amount of applied pesticide is greatly reduced by using it in the GF-120 food-bait, becoming an environmentally friendly strategy against tephritid flies (Michaud, 2003; Williams et al., 2003). Previous studies performed under laboratory conditions demonstrated that this spinosad-poisoned bait has a negative impact only on non-target flies (Wang & Messing, 2006). Scalercio et al. (2010) pointed out that baited and unbaited olive groves inhabit the same density of flying insects, suggesting no attractions of the GF-120 toward non-target insects. However, field evidences on the selective attraction of this bait must be better evaluated because similar abundances of non-target insects within baited and unbaited groves can conceal an attraction explained at a micro-scale leaving unchanged population densities at farm scale.

The aim of this paper is to evaluate the selectivity of GF-120 bait toward target and non-target insects, such as pollinators, under field conditions, those really experienced by the wild populations of insects.

**Materials and Methods**

Field trials were carried out in a 20 years old olive orchard, in the municipality of Rende, Southern Italy. The experimental olive grove covered 1.4 hectare-sand included 676 olive trees. The survey started in the middle of September 2008 and lasted one month.

Twenty-four white sticky plastic traps (size: 17×25×0.3 cm) were distributed in the olive grove (planting frame: 6×4 m) (Fig. 1). Traps were positioned at 150 cm above the soil, near the olive tree canopy. A commercial synthetic rat glue diluted with petrol ether was utilised to stick traps dipping them into the solution. Two traps, one baited and one unbaited, represented an experimental unit, for a total of 12 experimental units. Within any experimental unit the traps were positioned on the opposite side of the same tree to reduce the effect of location on the results. For the same reason the position of baited and unbaited traps was inverted every seven days. At the end of the survey a total of 24 samples was obtained, 12 from baited traps and 12 from control traps.

According to the label of the commercial product, the required amount of active ingredient (a.i.) for tephritid flies control is 0.24 g per hectare/ per week, equivalent to 1 L of commercial product diluted with 4 L of water. It is usually applied by spraying a small spot (diameter: 30 cm) of the tree foliage on the 50% of trees.

We applied 5 mL of solution on each trap with a brush every 2 days in order to maintain the attractiveness of the bait and respect the rate of a.i. per spot on the tree foliage suggested on the label.

Relative abundance of some orders of insects and of the target pests species Bactrocera oleae and Ceratitis capitata was weekly assessed (Tab. 1). Abundance data of Diptera Muscidae, other Diptera (all Diptera excluding Muscidae, B. oleae and C. capitata), Hymenoptera Formicidae, Hymenoptera Ichneumonoidea, other Hymenoptera (all Hymenoptera excluding Formicidae and Ichneumonoidea), Coleoptera, Ephemeroptera, Homoptera Cicadellidae, Lepidoptera, Heteroptera, Mecoptera, Blattoidea, Neuroptera, Trichoptera, and Orthoptera were recorded. Insects smaller than 2 mm were excluded from our analysis because their identification and quantification are very hard on sticky traps.

The bait effectiveness against target tephritid species was tested. A particular attention was focused onto the capture of pollinators, putatively the non-target insects most sensitive to sugar-based baits, and predators, a group of insects useful for conservative biological control strategies against some insect pests.

Data were analysed by using ANOVA followed by a least significant difference (LSD) post-hoc test.
RESULTS

A total of 12,180 insects belonging to the selected taxa was collected (Tab. 1), the 66.9% of which were Diptera. Formicidae represents the most abundant non-dipteran taxon, because during our field work a very large number of winged ants left their nests. Also Coleoptera and Lepidoptera were abundant in our samples, but lesser than expected. A very small number of Hymenoptera was collected (Tab. 1).

Baited traps collected significantly more insects than unbaited ones, but the abundance of non-dipteran insects was not affected by bait (Tab. 1). Diptera are strongly attracted by bait, especially the target species Bactrocera oleae and Ceratitis capitata, which are ten times more abundant on baited devices (Tab. 1). No significant attraction was detected for any non-dipteran taxon, neither separately nor cumulatively analysed. Furthermore, a highly significant repellent effect seems to be experienced by Cicadellidae, that occurred more abundantly on unbaited traps (Tab. 1). Pollinators such as Muscidae, Hymenoptera and Lepidoptera did not show preferences for baited traps. Parasitoids (Ichneu-
monoidea) and predators (Neuroptera), very scarcely represented in our samples, were not attracted by bait (Tab. 1).

DISCUSSION AND CONCLUSIONS

The main finding of this research is that non-dipteran insects, and particularly pollinators such as Lepidoptera and Hymenoptera, are not attracted by the poisoned bait under field conditions, those really experienced by wild insect communities. The toxicity of spinosad on honeybees, and pollinators in general, has been demonstrated under laboratory conditions (Mayes et al., 2003; Miles, 2003). Honeybees, strongly declining in agro-ecosystems throughout the world (Vanengelsdorp et al., 2008), could be exposed to an increasing risk if sugar-based poisoned baits are used on large areas, mainly in Mediterranean countries, where control strategies of olive and citrus tephritid flies can utilise such kind of bait. During our study only three honeybees (data not shown) have been captured by sticky traps, although a wild hive was located only 25 metres from the experimental field.

Lepidoptera are usually attracted by artificial sugar-based bait (Süssenbach & Fiedler, 1999), and the application of the GF-120 should be detrimental for this group of insects. This risk is increased by the scarcity of natural nectar sources in Mediterranean areas during late summer and early autumn. Our data demonstrate that the GF-120 is not attractive for this insect group, showing no negative impact on moths and butterflies.

Target and non-target Diptera are significantly attracted by the bait with the exception of Muscidae. The attraction toward target tephritids is largely expected, while the attraction toward some non-target Diptera could be a problem from a conservation point of view. Diptera provide several ecological services, e.g., as biological control agents of weeds and pests, and include endemic species. The indiscriminate use of GF-120 bait can cause the reduction of population of important dipteran species, mainly in islands (Wang & Messing, 2006). Faunistic knowledge on Diptera is very scarce and the distribution of species in the Mediterranean Basin is poorly known. In order to minimize the

Tab. 1. Mean abundance of insects collected by baited and unbaited traps. Insects smaller than 2 mm were not taken into account.

| Insect Group                  | Baited traps | Unbaited traps | $F_{1,12}$ | P    |
|------------------------------|--------------|----------------|-----------|------|
| Diptera Muscidae             | 265.2        | 219.1          | 1.30      | 0.270|
| Bactrocera oleae             | 40.3         | 3.4            | 14.41     | <0.01|
| Ceratitis capitata           | 18.6         | 0.8            | 8.73      | <0.01|
| Other Diptera                | 93.4         | 38.8           | 13.92     | <0.01|
| Hymenoptera Formicidae       | 114.3        | 142.3          | 0.26      | 0.612|
| Hymenoptera Ichneumonoidea   | 0.8          | 0.8            | 1.0       | 1    |
| other Hymenoptera            | 6.3          | 4.3            | 2.68      | 0.116|
| Coleoptera                   | 18.5         | 19.1           | 0.01      | 0.912|
| Ephemeroptera                | 0.1          | 0.2            | 0.34      | 0.564|
| Homoptera Cicadellidae       | 1.7          | 3.8            | 6.37      | 0.020|
| Lepidoptera                  | 8.5          | 6.2            | 4.01      | 0.058|
| Heteroptera                  | 2.3          | 3.2            | 0.97      | 0.334|
| Mecoptera                    | 0.4          | 0.5            | 0.07      | 0.786|
| Blattoidea                   | 0.08         | 0.17           | 0.34      | 0.564|
| Neuroptera                   | 0.6          | 0.3            | 1.56      | 0.226|
| Trichoptera                  | 0            | 0.3            | 5.25      | 0.032|
| Orthoptera                   | 0.2          | 0.6            | 3.52      | 0.074|
| Total insects                | 571.3        | 443.8          | 4.57      | 0.044|
| Total non-dipteran insects   | 153.8        | 181.7          | 0.26      | 0.613|
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risk for beneficial and rare fly species, it should be important to increase knowledge on this taxonomic group in geographic areas where the target tephritid species are important pests on olive and citrus.

This is the first paper aimed to study the selectivity under field conditions of GF-120, a spinosad-poisoned bait. The experimental design recreates environmental conditions really experienced by insects, taking a picture of their abundance within the olive grove in study. Pollinators, a key group for the ecosystem functioning especially in cultivated lands, were not affected by spinosad-poisoned bait, underlining the sustainability of this control method against two of the major pests of permanent crops worldwide. The need of pest control strategies safe for environment and wild populations of non-target organisms seems to be satisfied by this technique, more and more applied for area-wide integrated pest management.

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