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Tachinidae (Diptera) collected in traps used for mass-trapping of *Bactrocera oleae* (Rossi) (Diptera: Tephritidae) in olive groves in Central Spain

H-P. Tschorsnig[1], E. Seris[2], A. Cobo[2], G. Cobos[2], S. Pascual[2], J. P. Ros[2] and M. Gonzalez-Nuñez[2]*

[1] Staatliches Museum für Naturkunde (SMNS), Rosenstein 1, 70191 Stuttgart, Germany
[2] Plant Protection Department, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), Carretera de La Coruña Km 7.5, 28040 Madrid, Spain

Abstract

Tachinid flies are important for biological control of pests, because most species are parasitoids of insects. The objectives of this work were 1) to describe the species of tachinid flies captured by mass trapping devices against the olive fruit fly, *Bactrocera oleae*, in olive groves in Central Spain, and 2) to report on the selectivity of the different devices for this important group of insects. The study was carried out in two olive groves in the province of Madrid during 2005 and 2008. The number of trapping devices was five in 2005 and twelve in 2008. A total of 66 species of tachinid flies was captured. Comments on some of them are provided because of their special interest. Three tachinid species (*Clemelis massilia*, *Schembria meridionalis* and *Ceromya flaviseta*) are recorded from the Iberian Peninsula for the first time. It is remarkable that captures of *C. massilia* accounted for 72.3% in 2008. Comparison of the different mass-trapping devices indicates that none of them is selective for this important family of parasitoids. Numbers of tachinid flies captured per trap and season ranged between 1 and 13 in 2005, and 24 and 283 in 2008. This is the first study carried out in Spain on tachinids captured by mass-trapping devices and it reports the abundance and species diversity of this group of insects in olive groves as well as the poor selectivity of mass-trapping on them.

Additional key words: *Ceromya flaviseta; Cestonia cineraria; Clemelis massilia; Mintho compressa; Schembria meridionalis;* side-effects.

Resumen

Taquínidos (Diptera) capturados en trampas para trampeo masivo de *Bactrocera oleae* (Rossi) (Diptera: Tephritidae) en olivares del centro de España

Los taquínidos son importantes para el control biológico de plagas, ya que en su mayoría son parasitoides de insectos. Los objetivos de este trabajo fueron: 1) describir las especies de taquínidos capturados por dispositivos de trampeo masivo para la mosca del olivo, *Bactrocera oleae*, en olivares del centro de España, y 2) conocer la selectividad de los distintos dispositivos para este grupo de insectos. El estudio se llevó a cabo durante 2005 y 2008 en dos olivares de la provincia de Madrid. Se emplearon cinco dispositivos de trampeo masivo en 2005 y doce en 2008. El número total de especies de taquínidos capturadas fue 66. Algunas de ellas se comentan en detalle en virtud de su especial interés. Se cita por primera vez la presencia en la Península Ibérica de tres especies de taquínidos (*Clemelis massilia*, *Schembria meridionalis* y *Ceromya flaviseta*). Es destacable que el 72,3% de las capturas en 2008 fue de *C. massilia*. La comparación de los diferentes dispositivos de trampeo masivo indica que ninguno de ellos es selectivo para este importante grupo de parasitoides. El número de taquínidos capturados por trampa y temporada varió entre 1 y 13 en 2005, y entre 24 y 283 en 2008. Este es el primer estudio llevado a cabo en España sobre taquínidos capturados por dispositivos de trampeo masivo e indica la abundancia y diversidad de especies de estos insectos en los olivares, así como la pobre selectividad del trampeo masivo frente a ellos.

Palabras clave adicionales: *Ceromya flaviseta; Cestonia cineraria; Clemelis massilia;* efectos secundarios; *Mintho compressa; Schembria meridionalis*.

*Corresponding author: mgnunez@inia.es
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Introduction

Tachinid flies (Diptera: Tachinidae) are important natural enemies of insect pests, especially lepidopterous insects, and have often been used in biological control (Grenier, 1988). They are koinobiont parasitoids, attacking in most cases larval hosts, and can be found in most habitats (Stireman *et al.,* 2006). In olive groves (*Olea europaea* Linnaeus, 1753), tachinids could contribute to biological control of important pest species such as *Prays oleae* (Bernard, 1788) or *Palpita vitrealis* (Rossi, 1794). Although there are no studies giving quantitative information on this contribution, there are reports on tachinids parasitizing olive pests. In review papers by Arambourg (1969) and Cerretti and Tschorsnig (2010) the tachinids *Phytomyptera nigrina* (Meigen, 1824) and *Nemorilla maculosa* (Meigen, 1824) are cited as parasitoids on *P. oleae* and *P. vitrealis*, respectively.

In Spain pest control programs in olive groves are focused mainly on the olive fruit fly, *Bactrocera oleae* (Rossi, 1790), which is the key pest of this crop. One of the control methods available to control *B. oleae* is mass-trapping. However, the use of traps may have an adverse effect on non-target insects, especially on insects belonging to the order Diptera, in which the family Tachinidae is considered of highest importance among the beneficial ones.

Preliminary results on undesired side effects of mass-trapping of *B. oleae* have shown that the different devices commonly used for this control method capture a large number of non-target arthropods (Seris *et al*., 2010). Predators of 35 different families and parasitoids of 26 families were captured by the traps. The most important family of parasitoids captured was Tachinidae (about 80% of the parasitoids were Tachinidae). Other studies have reported that the family Tachinidae forms the largest component of the predator-parasite guild present in surveillance traps used for Mexican fruit flies (Thomas, 2003).

To better understand an agroecosystem we must know not only the amount of non-target arthropods affected by control methods, but also the species to which they belong. It is important to determine the species of tachinid flies present in our agroecosystem in order to know to what extent they could contribute to natural control of insect pests in olive groves. Thus, the objective of this work was two-fold: first, to carry out a taxonomic study to determine the tachinid species captured by mass-trapping devices, and second, to compare different devices regarding their negative impact on tachinids as a whole. To our knowledge, this is the first taxonomic study on tachinids captured by traps in olive groves carried out in Spain.

Material and methods

Specimens were captured in two olive groves near Villarejo de Salvanés (southeastern Madrid, Spain). The area sampled in 2005 is located about 8 km south of Villarejo de Salvanés (40.106766N, 3.273411W, 690 m) and it is surrounded by agricultural landscape and wasteland (Figure 1a). In 2008 the olive grove was about 3 km northeast of Villarejo de Salvanés (40.178841N 3.249507W, 760 m). It is a mixed vine and olive field (Figure 1b).

Five and twelve different mass-trapping devices were used in 2005 and 2008, respectively. These were

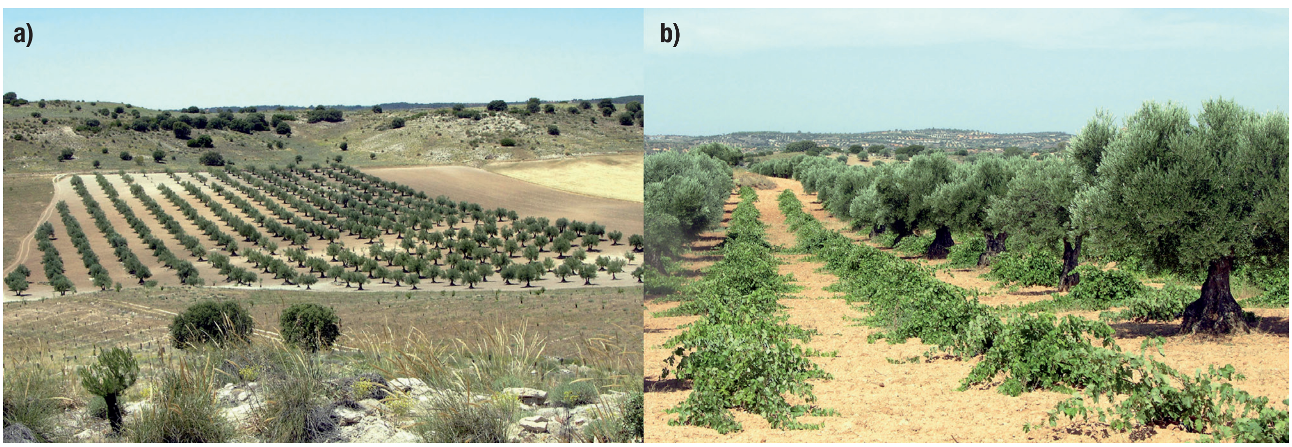

Figure 1. Olive groves used in 2005 (a) and 2008 (b) for mass-trapping trials.

Table 1. Combinations of traps and attractants used in the mass-trapping field trials in 2005 and 2008

Combination	Trap type	Attractant	2005	2008
1	McPhail trap (Fig. 2a)	Diammonium hydrogen phosphate	x	
2	Easy trap® (Fig. 2b)	Diammonium hydrogen phosphate		x
3	Easy trap®	Nulure®	x	x
4	Easy trap®	Tephri-lure®		x
5	Probodelt® (Fig. 2c)	Nulure®	x	
6	Olipe (Fig. 2d)	Diammonium hydrogen phosphate	x	x
7	Olipe	Nulure®	x	x
8	Olipe	Tephri-lure®		x
9	Tephri-trap® (Fig. 2e)	Diammonium hydrogen phosphate		x
10	Tephri-trap®	Nulure®		x
11	Tephri-trap®	Tephri-lure®		x
12	Tephri-trap Ecological® (Fig. 2f)	Diammonium hydrogen phosphate		x
13	Tephri-trap Ecological®	Nulure®		x
14	Tephri-trap Ecological®	Tephri-lure®		x

combinations of traps and attractants, as described in Table 1. The traps used in the study (Figure 2) are designed for mass-trapping and monitoring of different fruit flies, including *B. oleae*. The attractants are commonly used for mass-trapping of tephritids and they were prepared according to the manufacturer's directions. Nulure® and Tephri-lure® are protein hydrolysates. Diammonium hydrogen phosphate was added at a 4% rate.

The period sampled in both years was from June to November and attractants were replaced every other week. One trap was hung per tree and four and three replicates were set up for each combination of trap and attractant in 2005 and 2008, respectively. In 2005, an additional trap (Easy trap® + Nulure®) was placed on a holm oak (*Quercus ilex* Linnaeus, 1753) next to the olive grove. In both years traps were hung in contiguous trees in a homogeneous area in the centre of the olive groves.

Trapped arthropods were collected by filtering the bait when it was replaced. Specimens were determined to family level at the Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), Madrid, Spain. The majority of the captured tachinids were sent for determination to the first author, at the Staatliches Museum für Naturkunde (SMNS), Stuttgart, Germany.

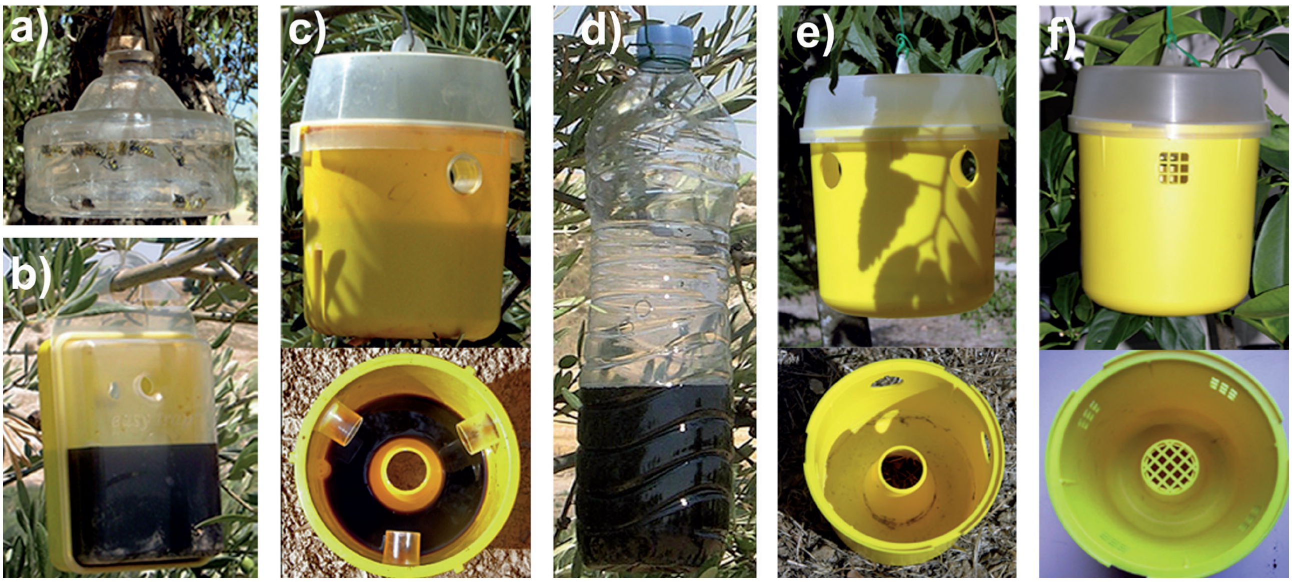

Figure 2. Trapping devices used in the field trials: a) McPhail®; b) Easy trap®; c) Probodelt®; d) Olipe; e) Tephri-trap®; f) Tephri-trap Ecological®.

Some specimens were not sent because they were in poor condition and, although recognizable as tachinids, they were not suitable for species identification.

After identification, the tachinid flies were sent back and stored at the INIA, except *Neophryxe vallina* (Rondani, 1861), several duplicate specimens of *Rioteria submacula* Herting, 1973, *Clemelis massilia* (Herting, 1977) and *Schembria meridionalis* Rondani, 1861, and one duplicate specimen of *Athrycia impressa* (van der Wulp, 1869) which were preserved at SMNS.

Statistical analysis

Analysis of variance was carried out on number of tachinids per trap and season captured by the different mass-trapping devices. After analysis, mean values were compared by a Tukey HSD test ($p \leq 0.05$). Statistical tests were performed using the software Statgraphics® Centurion XV (StatPoint, 2005).

Results and discussion

Captured species

Total of 155 specimens of Tachinidae, belonging to 32 species, and 3,465 specimens, belonging to 55 species, were captured in 2005 and 2008, respectively. The total number of species reported in this study is 66. From the whole numbers of arthropods collected, 1.7% in 2005 and 2.4% in 2008 were tachinids. They were the most important group of parasitoids captured both in 2005 (65.6%) and 2008 (83.2%).

The relative abundance of the different species of tachinids was low, with percentages from the total numbers of tachinids lower than 20%, except *C. massilia*, captures of which accounted for 72.3% of all tachinids in 2008. Table 2 lists the species in the order of the relevant catalogue of Herting and Dely-Draskovits (1993). The number of males and females is given for each year. Additionally, summarised information on the hosts is provided, based on published and unpublished data compiled by Tschorsnig for many years. A single host species mentioned in this table does not necessarily mean that the respective tachinid is a specific parasitoid of that host species because it might simply be the only host record known so far. In case of Lepidoptera, the larval stage is the host; for other host orders the parasitized stage is detailed in Table 2. Only 11 specimens out of the 155 captured in 2005 were captured in the holm oak trap.

Members of three of the four subfamilies of Tachinidae (Exoristinae, Tachininae and Dexiinae) were well represented in the traps, whereas only two specimens of a single species belonged to the fourth tachinid subfamily, Phasiinae (parasitoids of adult Heteroptera). It remains unknown why the traps were not attractive for members of this subfamily. Small species (7 mm in body length or less) accounted for 93% of the collected specimens and only 7% were larger ones (up to 12 mm).

It is striking that parasitoids of typical olive tree pests were nearly absent among the collected Tachinidae. There are only two specimens of *P. nigrina*, a species which is known from *P. oleae*, among other microlepidopterous hosts. Similarly only four specimens of *N. maculosa*, and 40 specimens of *Pales pavida* (Meigen, 1824) were caught, both being unspecialised species including *P. vitrealis* as host. *C. massilia* is a special case (see below under the heading "Remarks on species of special interest").

Tachinidae are robust, excellent flyers. Therefore, there is no guarantee that the hosts of the collected species develop in the experimental areas. In certain cases this is obviously true, *e.g.* for *Phryxe caudata* (Rondani, 1859) which needs pine trees for its host *Thaumetopoea pityocampa* (Denis and Schiffermuller, 1775).

Remarks on species of special interest

All but three species of Tachinidae captured have already been recorded from the Iberian Peninsula (Tschorsnig and Báez, 2002). For more detailed information see Tschorsnig (1992) and Tschorsnig *et al*. (1997). The following five species deserve further comment.

Cestonia cineraria Rondani, 1861

The last record of this species from the Iberian Peninsula dates from more than 100 years ago (Czerny and Strobl, 1909).

Clemelis massilia (Herting, 1977)

This species was by far the most common tachinid found during this investigation (72.3% of all specimens

Table 2. Tachinidae captured by devices used in mass-trapping of *Bactrocera oleae* in olive groves in Madrid, during 2005 and 2008

Species	Number of specimens		Hosts
	2005	2008	
Subfamily Exoristinae			
Exorista civilis (Rondani, 1859)	1 ♂, 1 ♀	1 ♀	*Loxostege sticticalis* Linnaeus (Pyralidae), occasionally other Pyralidae, Noctuidae or Geometridae
Exorista nympharum (Rondani, 1859)		2 ♂♂, 8 ♀♀	Unknown
Exorista rendina Herting, 1975	10 ♂♂, 1 ♀	1 ♂	*Etiella zinckenella* Treitschke (Pyralidae)
Exorista segregata (Rondani, 1859)(1)	2 ♂♂, 7 ♀♀	23 ♂♂, 7 ♀♀	Unspecific (Lymantriidae, Zygaenidae, Noctuidae, Lasiocampidae, Arctiidae, Thaumetopoeidae, Nymphalidae, Pieridae, Saturniidae)
Exorista sp.(2)		1 ♂	Lepidoptera
Neophryxe vallina (Rondani, 1861)		1 ♂, 1 ♀	*Meganola togatulalis* Hübner (Nolidae), Pyralidae sp.
Chetogena acuminata Rondani, 1859(1)	9 ♂♂, 18 ♀♀	18 ♂♂, 32 ♀♀	Larvae of Tenebrionidae
Phorocera assimilis (Fallén, 1810)		1 ♀	Noctuidae, Geometridae
Meigenia mutabilis (Fallén, 1810)		9 ♂♂	Larvae of Chrysomelidae and Tenthredinidae
Meigenia simplex Tschorsnig and Herting, 1998		21 ♂♂	Larvae of Chrysomelidae
Meigenia mutabilis-group ♀♀(3)		64 ♀♀	Larvae of Chrysomelidae
Zaira cinerea (Fallén, 1810)	1 ♂	1 ♂	Imagines of Carabidae (*Carabus*, *Harpalus*, *Pterostichus*, *Zabrus*, *Amara*, *Broscus*)
Gastrolepta anthracina (Meigen, 1826)		1 ♂	Larvae of *Lagria hirta* Linnaeus (Lagriidae)
Rioteria submacula Herting, 1973	3 ♀♀	11 ♂♂, 22 ♀♀	Unknown
Ligeria angusticornis (Loew, 1847)		1 ♂, 8 ♀♀	Pterophoridae
Compsilura concinnata (Meigen, 1824)		6 ♂♂, 9 ♀♀	Many Lepidoptera families, rarely larvae of Tenthredinidae
Ceracia mucronifera Rondani, 1865	1 ♀		Adults of Acrididae
Ethilla aemula (Meigen, 1824)		1 ♀	Geometridae
Paratryphera barbatula (Rondani, 1859)		1 ♂	*Scopula* spp. (Geometridae)
Nemorilla maculosa (Meigen, 1824)	1 ♂, 3 ♀♀	24 ♂♂, 12 ♀♀	Numerous Microlepidoptera, rarely also a few Macrolepidoptera
Aplomya confinis (Fallén, 1820)		13 ♂♂, 10 ♀♀	Lycaenidae
Phryxe caudata (Rondani, 1859)		2 ♀♀	*Thaumetopoea pityocampa* Schiffermüller, rarely other Thaumetopoidae
Phryxe vulgaris (Fallén, 1810)		3 ♂♂, 12 ♀♀	Many Lepidoptera families
Chetina setigena Rondani, 1856		4 ♂♂, 1 ♀	Lycaenidae
Drino atropivora (Robineau-Desvoidy, 1830)		2 ♀♀	*Acherontia atropos* Linnaeus, rarely other Sphingidae
Thelyconychia solivaga (Rondani, 1861)		4 ♂♂, 4 ♀♀	Confirmed hosts unknown
Tryphera lugubris (Meigen, 1824)		2 ♂♂	Arctiidae, Syntomididae
Cestonia cineraria Rondani, 1861	1 ♀		*Archips xylosteana* Linnaeus (Tortricidae)
Alsomyia olfaciens (Pandellé, 1896)		1 ♂, 1 ♀	*Zygaena* spp. (Zygaenidae)
Clemelis massilia (Herting, 1977)(1)	8 ♂♂, 17 ♀♀	1,334 ♂♂, 1,172 ♀♀	Unknown
Clemelis pullata (Meigen, 1824)		1 ♂	*Loxostege sticticalis* Linnaeus and some other Pyralidae, also a few Psychidae, Scythrididae and Tortricidae
Pales pavida (Meigen, 1824)	1 ♂, 1 ♀	2 ♀♀	Numerous Macrolepidoptera, a few Microlepidoptera
Schembria meridionalis Rondani, 1861		20 ♂♂, 12 ♀♀	Unknown
Ceromasia rubrifrons (Macquart, 1834)	3 ♂♂, 1 ♀	2 ♀♀	*Zygaena* spp. (Zygaenidae), rarely some Lymantriidae, Geometridae, Arctiidae, Hesperiidae, Nymphalidae and Pieridae
Ocytata pallipes (Fallén, 1820)		5 ♂♂, 6 ♀♀	*Forficula* spp. (Forficulidae)
Prosopea nigricans (Egger, 1861)	1 ♀		Arctiidae (*Lithosia*, *Paidia*, *Eilema*, *Tyria*)
Gaedia connexa (Meigen, 1824)		1 ♂, 1 ♀	Unknown
Pseudogonia rufifrons (Wiedemann, 1830)	1 ♀		Noctuidae (*Agrotis*, *Leucania*, *Mamestra*, *Apamea*, *Spodoptera*, *Heliothis*)
Subfamily Tachininae			
Tachina magnicornis (Zetterstedt, 1844)		1 ♂	Noctuidae
Peleteria iavana (Wiedemann, 1819) [syn. *varia* (Fabricius, 1794)]		2 ♂♂, 10 ♀♀	Noctuidae

Table 2 (cont.). Tachinidae captured by devices used in mass-trapping of *Bactrocera oleae* in olive groves in Madrid, during 2005 and 2008

Species	Number of specimens		Hosts
	2005	2008	
Peleteria rubescens (Robineau-Desvoidy, 1830)		2 ♂♂, 2 ♀♀	Noctuidae
Peleteria ruficornis (Macquart, 1835)		1 ♀	Unknown
Linnaemya lithosiophaga (Rondani, 1859)	1 ♂	8 ♀♀	*Eilema caniola* Hübner (Arctiidae)
Linnaemya vulpina (Fallén, 1810)		9 ♂♂, 12 ♀♀	Noctuidae
Macquartia tessellum (Meigen, 1824)	4 ♂♂, 1 ♀		Larvae of Chrysomelidae (*Chrysolina*, *Phytodecta*, *Colaphellus*, *Entomoscelis*)
Phytomyptera nigrina (Meigen, 1824)		1 ♂, 1 ♀	Various Microlepidoptera
Graphogaster vestita Rondani, 1868	1 ♂, 1 ♀	1 ♀	Unknown
Ceromya flaviseta (Villeneuve, 1921)	1 ♀		Unknown
Actia infantula (Zetterstedt, 1844)		3 ♂♂, 12 ♀♀	*Monopis laevigella* Denis and Schiffermüller (Tineidae)
Peribaea apicalis Robineau-Desvoidy, 1863	2 ♂♂	14 ♂♂, 24 ♀♀	Geometridae (*Ematurga*, *Ennomos*, *Erannis*, *Alsophila*, *Apocheima*)
Peribaea discicornis (Pandellé, 1894)	1 ♂	1 ♂	Unknown
Peribaea tibialis (Robineau-Desvoidy, 1851)	1 ♀	11 ♂♂, 15 ♀♀	Noctuidae, rarely other families of Macrolepidoptera
Aphantorhaphopsis [formerly in *Ceranthia*] *selecta* (Pandellé, 1894)	1 ♂, 1 ♀	1 ♀	*Paidia rica* Freyer (Arctiidae)
Mintho compressa (Fabricius, 1787)		1 ♂	Unknown
Mintho rufiventris (Fallén, 1817) [(1)]	1 ♂, 4 ♀♀	173 ♂♂, 191 ♀♀	*Hypsopygia glaucinalis* Linnaeus, *Apomyelois ceratoniae* Zeller (Pyralidae), *Bembecia ichneumoniformis* Denis and Schiffermüller (Sesiidae)
Minthodes [formerly in *Pseudomintho*] *diversipes* (Strobl, 1899)[(1)]	12 ♂♂, 16 ♀♀	4 ♂♂, 11 ♀♀	Unknown
Subfamily Dexiinae			
Campylocheta inepta (Meigen, 1824)	1 ♂, 1 ♀	5 ♂♂, 4 ♀♀	Mostly Geometridae, occasionally also Noctuidae or other Macrolepidoptera
Ramonda prunicia (Herting, 1969)	2 ♀♀		Noctuidae
Periscepsia carbonaria (Panzer, 1798)	1 ♂		*Agrotis* spp., *Euxoa obelisca* Schiffermüller (Noctuidae)
Periscepsia handlirschi (Brauer and Bergenstamm, 1891)	2 ♀♀		Unknown
Athrycia impressa (van der Wulp, 1869)[(4)]	2 ♂♂	1 ♂	*Anarta myrtilli* Linnaeus, *Sideridis lampra* Schawerda (Noctuidae), *Rhyparia purpurata* Linnaeus (Arctiidae)
Voria ruralis (Fallén, 1810)		35 ♂♂, 3 ♀♀	*Plusia* and allied genera (Noctuidae), occasionally other Macrolepidoptera
Cyrtophleba ruricola (Meigen, 1824)	1 ♂, 1 ♀		Noctuidae (mainly *Apopestes spectrum* Esper), *Pachycnemia hippocastanaria* Hübner (Geometridae)
Stomina calvescens Herting, 1977	3 ♀♀	2 ♀♀	Unknown
Rondania rubens Herting, 1969	1 ♀		Unknown, but probably adults of Coleoptera
Subfamily Phasiinae			
Leucostoma sp.[(5)]		1 ♂, 1 ♀	Adults of Heteroptera

[(1)] Specimens of these taxa were collected in 2005 from both the olive grove and the holm oak. [(2)] *Exorista* sp. cannot be determined with certainty to species level. The specimen is a damaged male, only 8 mm in body length, belonging either to *E. grandis* (Zetterstedt, 1844) or *E. sorbillans* (Wiedemann, 1830). [(3)] Females of the *Meigenia mutabilis*-group are unidentifiable; they might belong to *M. mutabilis*, *M. simplex* or another species of this group. [(4)] A thorough revision of the genus *Athrycia* may show this is not quite the same as *A. impressa*. [(5)] An identification of *Leucostoma* sp. to species level was not possible because the material was in bad condition.

in 2008). No host records are known, but according to its abundance, it is likely that *C. massilia* plays (or at least played during 2008) an important role on the experimental area or at least nearby. The ptilinum was improperly retracted in about 20% of the collected specimens, which indicates that they most probably had entered the traps soon after emergence. This also implies that their host must have developed not far away from the traps. Furthermore it may be concluded from the more or less uniform dimension of this tachinid, *i.e.* variation of the body length between 4.5 and 5.5 mm (only single specimens being smaller, up to 3.5 mm, or larger, up to 7 mm), that *C. massilia* probably develops in a single host species. The pyralid moth *P. vitrealis*, regularly found in low numbers in an olive plantation near the study area, would perhaps be a potential host, but there was no rearing or direct observation to support this suggestion. Wood-boring hosts, such as *Euzophera pinguis* (Haworth, 1811), can be ruled out because the small eggs of *Clemelis* are laid on leaves and must be swallowed by the feeding caterpillars.

C. massilia was described from southern France by Herting (1977) and later it was also found in Tenerife (Tschorsnig and Báez, 2002) and Italy (Cerretti, 2004). The species was not yet recorded from the Iberian Peninsula, but it is probable that some older identifications of the very similar species *Clemelis pullata* (Meigen, 1824) might refer to *C. massilia*. The separation of both species is sometimes difficult because several characters (head width, distance between the posterior ocelli, thickening of the arista) overlap. The most reliable character is the male genitalia as described by Herting (1977). Females often remain doubtful (but were assignable to *C. massilia* in the present investigation).

Schembria meridionalis Rondani, 1861

This is a rare species which was collected in the traps in relatively large numbers (32 specimens). *S. meridionalis* was only known before as a few specimens from Malta, Sicily and Israel (Herting and Dely-Draskovits, 1993; Cerretti, 2005). This is the first record of this species from the Iberian Peninsula. Nothing is known on its hosts.

The collected specimens of *S. meridionalis* have a remarkably variable body length (between 3.9 and 8.0 mm). Also the petiole of the wing cell R4+5 is of variable length, between slightly less than diameter of vein M to slightly longer than half of crossvein r-m.

Ceromya flaviseta (Villeneuve, 1921)

This species is mainly distributed in temperate Europe and this is the first record from the Iberian Peninsula.

Mintho compressa (Fabricius, 1787)

Only the holotype of *M. compressa* was previously known from Spain, described by Fabricius (1787) without exact location, so this is only the second record for the Iberian Peninsula in more than 200 years. However, the species is widely distributed and common in other Mediterranean countries and it is not known why *M. compressa* is so rare in the Iberian Peninsula.

Comparison of trapping devices

The mean number of tachinid specimens collected by the different combinations of trap + lure tested in 2005 and 2008 are given in Table 3. As commented in the materials and methods, in 2008 a number of specimens were determined as tachinids but it was not possible their determination at species level.

Other studies of the side effects of mass-trapping on non-target arthropods have reported no captures of tachinids. Porcel *et al*. (2009) studied the effect of the Olipe mass-trapping (Figure 2d) on olive non-target arthropods, and they found a high proportion of non-target Diptera captured but they did not report their families. On the other hand, in the study by Thomas (2003) on non-target insects captured in Mexican fruit fly surveillance traps, tachinids accounted for 58% of the predator-parasite guild.

The number of tachinids captured in 2005 was much lower than that in 2008. The two field trials were carried out, apart from different years, at different locations (Figure 1), and the two olive groves differed in features relevant to the arthropod fauna expected to be present in the canopy, such as surrounding landscape, crop age, soil type and cover, etc.

When comparing the devices, in 2005, the McPhail trap baited with diammonium hydrogen phosphate was the one that captured the lowest number of tachinids (Table 3). No significant differences were observed amongst the catches in other four devices studied, the Probodelt trap baited with the attractant Nulure capturing the highest number of specimens (Table 3). When comparing numbers captured in the three traps baited with the

Table 3. Number of tachinid specimens captured per trap and season during 2005 and 2008

Year	Trap type	Attractant	Tachinids captured (Mean ± standard error) (1)
2005	McPhail®	Diammonium hydrogen phosphate	1.00 ± 0.71 c
	Olipe	Diammonium hydrogen phosphate	8.75 ± 0.85 ab
	Olipe	Nulure®	6.25 ± 1.31 b
	Easy trap®	Nulure®	7.00 ± 1.47 b
	Probodelt®	Nulure®	13.00 ± 0.91 a
2008	Easy trap®	Diammonium hydrogen phosphate	50.33 ± 16.58 bc
	Easy trap®	Nulure®	120.67 ± 8.51 abc
	Easy trap®	Tephri-lure®	127.00 ± 44.84 abc
	Tephri-trap Ecological®	Diammonium hydrogen phosphate	213.33 ± 54.12 ab
	Tephri-trap Ecological®	Nulure®	283.00 ± 99.23 a
	Tephri-trap Ecological®	Tephri-lure®	105.00 ± 30.55 abc
	Tephri-trap®	Diammonium hydrogen phosphate	24.00 ± 5.20 c
	Tephri-trap®	Nulure®	113.67 ± 14.10 abc
	Tephri-trap®	Tephri-lure®	44.67 ± 6.44 bc
	Olipe	Diammonium hydrogen phosphate	65.00 ± 19.14 bc
	Olipe	Nulure®	58.67 ± 22.24 bc
	Olipe	Tephri-lure®	48.33 ± 19.84 bc

(1) Data are means of three replicates. Data followed by different letters for each year are significantly different according to Tuckey HSD test ($p \leq 0.05$).

same attractant Nulure, the Probodelt trap captured a significantly higher number than the Olipe and Easy traps.

In 2008, Tephri-trap Ecological baited with Nulure was the device that captured the highest number of tachinids, while the lowest value was for Tephri-trap baited with diammonium hydrogen phosphate (Table 3). The number of specimens captured by Olipe traps never reached those observed in the other traps with some of the attractants. On the other hand, Tephri-trap Ecological captured very high numbers of tachinids, regardless of the attractant. Tephri and Easy traps showed intermediate values. Regarding the attractants, no general pattern can be detected.

It is difficult to conclude which devices are most environmentally friendly. We have previously reported that there is a strong variation in the captures of *B. oleae* and other non-target arthropods in each individual trap (Seris *et al*., 2007, 2010), which indicates a high heterogeneity amongst the trees of the same olive grove. In this study we have avoided including trees which are on the edge of the groves, because of this heterogeneity, and we have used contiguous trees within a relatively homogeneous area inside the olive grove. However, there are individual features associated with each tree that cannot be avoided. To minimize this strong variation it would be desirable to carry out studies including a larger number of trees per treatment.

In spite of this, there are general trends that agree with the results of captures of other insects. Protein hydrolysates capture higher numbers of individuals than diammonium hydrogen phosphate. This same result has also been reported for *B. oleae* and non-target arthropods (Seris *et al*., 2010). Thomas (2003) reported also higher numbers of tachinids captured by proteinaceous attractants (Torula yeast) compared to synthetic lures (ammonium acetate and putrescine) and Gómez-Gómez *et al*. (2010) reported the attractiveness of carrion for tachinids. But there are still obvious knowledge gaps on lures which might be specifically attractive for Tachinidae. General trends concerning traps are that Olipe trap captures low numbers of arthropods, while the number of specimens captured by Probodelt trap is high, as reported previously (Seris *et al*., 2007, 2010).

Tephri-Trap Ecological is designed to reduce the captures of non-target arthropods. Based on this aim, it incorporates nets covering the entrance openings of the trap (Figure 2f). For some beneficial arthropods there was indeed a reduction in the number of captures by this device, such as chrysopids (Seris *et al.*, 2007, 2010). However, in this study Tephri-Trap Ecological did not exclude tachinids (Table 3), since all captured specimens were small enough to go through the net. Olipe and McPhail traps never caught high numbers of tachinids, and it is possible that the colour of the traps might have played a role here. Olipe and McPhail traps are transparent while Tephri-traps and Easy traps are yellow. Yellow colour is well-known as an attractant for many flying insects and is used for Tachinidae in yellow pan traps (Tschorsnig, 2002, 2008). It is important to bear in mind that the main objective of these traps is capturing as many *B. oleae* specimens as possible. Thus, the balance between efficacy and side effects must always be taken into account, along with the fact that mass-trapping is a more environmentally friendly control method for *B. oleae* than conventional chemical control (Haniotakis *et al*., 1991; Porcel *et al*., 2009).

This study has shown that there is a large number of tachinid species in the olive agroecosystem in central Spain, some of which have been reported here for the first time. The number of tachinids captured suggests that they could play an important role in the balance of the agroecosystem. However, further work should be carried out to clarify the impact of these species on natural pest control as well as to determine the impact of different mass-trapping devices on those relevant species.

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