

Hoverfly (Diptera: Syrphidae) diversity in Tapada da Ajuda, Lisbon – a preliminary study

Diversidade de sirfídeos na Tapada da Ajuda, Lisboa – estudo preliminar

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ABSTRACT

Hoverflies are holometabolic insects, whose adults are pollinators feeding on nectar and pollen. Frequently, they are confused with wasps, bees and bumblebees. In the larval stage, some of them prey other insects, specially aphids (Hemiptera), and others are saprophagous. For this reason, they are important biological control agents. In this study, we carried out the prospection and specific identification of hoverflies in four habitats in Tapada da Ajuda (olive grove, a field of Apiaceae, herbaceous vegetation near Lagoa Branca and plum orchard), between March and May 2017. Hoverfly adults were mostly captured with an entomologic net, but also with jar and plastic bags. A preliminary evaluation on the importance of ecologic infrastructure *fava bean inter-row* in the plum orchard was also performed. For this purpose, we observed fava plants and plum trees, collecting eggs, larvae and pupae of hoverflies that we reared in the laboratory until the emergence of the adult of hoverfly or parasitoid. A total of 12 species were identified, being the most frequent and abundant *Episyrphus balteatus* and *Sphaerophoria scripta*. Species richness was higher in the Apiaceae field although this habitat was sampled only during the last fortnight of the study. In the hoverfly immature collected in the plum orchard we detected hymenopteran parasitoids belonging to Diplazontinae and Pteromalidae.

Key words: biodiversity, ecological infrastructures, predator

RESUMO

Os sirfídeos são insetos holometabólicos cujos adultos são polinizadores, alimentando-se de néctar e pólen. São frequentemente confundidos com vespas, abelhas e abelhões. No estado larvar, algumas espécies predam outros insetos, nomeadamente afídeos (Hemiptera), outros são saprófagos. Os sirfídeos são, por isso, importantes agentes de proteção biológica. Neste trabalho, efetuou-se a prospeção e a identificação específica de sirfídeos na Tapada da Ajuda, em quatro habitats (olival, talhão de apiáceas junto ao olival, vegetação herbácea junto à Lagoa Branca e pomar de ameixeiras). Os adultos de sirfídeo foram capturados principalmente com o auxílio de rede entomológica, mas também recorrendo a frascos e sacos de plástico. Avaliou-se o papel da infraestrutura ecológica *faveiras* nas entrelinhas do pomar de ameixeiras na população de sirfídeos. Com essa finalidade, foram observadas faveiras nas entrelinhas e ameixeiras, recolhendo ovos, larvas e pupas de sirfídeo que foram criados em laboratório até emergência do adulto de sirfídeo ou de parasitóide. Identificaram-se 12 espécies, sendo as mais abundantes e frequentes *Episyrphus balteatus* e *Sphaerophoria scripta*. A riqueza específica foi mais elevada no talhão de Apiaceae, apesar de este habitat ter sido amostrado apenas no decurso da última quinzena do estudo. Nos imaturos de sirfídeo recolhidos no pomar de ameixeiras foram detetados parasitoides himenópteros das famílias Diplazontinae e Pteromalidae.

Palavras-chave: biodiversidade, infraestruturas ecológicas, predador

INTRODUCTION

There are more than 6200 species of Syrphidae all over the world in about 300 genera, and 3-4 not yet consensual subfamilies (Young *et al.*, 2016). Several hoverflies' species were reported in Portugal. Alexandre Gomes referred 55 and 65 species, in 1978 and in 1981, respectively (Gomes, 1978, 1981). Dirickx (1994) listed 74 species, and the "Iberian Diptera Checklist" listed 100 species, 86 in the mainland, 23 in Azores Islands and 23 in Madeira (Marcos-García *et al.*, 2002). GBIF database 63 species (GBIF, undated) in the mainland and Azores and Madeira Archipelagos. van Eck (2011) listed 52 genera and 172 species, belonging to three subfamilies, Microdontinae, Eristalinae and Syrphinae; Eristalinae presented the largest number of species. In 2016, the same author listed more 28 species to the mainland, increasing the total number to 195 species (van Eck, 2016).

All or almost all adult hoverflies are flower visitors, feeding on nectar and pollen (Schneider, 1969; Rojo *et al.*, 2003) as well as honeydew, and are important pollinators. On the other hand, larval feeding strategies are very diverse. Some species are saprophagous in diverse media, some other are mycophagous, a few are phytophagous, but predation is one of the most common feeding strategy (Rotheray and Gilbert, 1999; Sommaggio, 1999; Rojo *et al.*, 2003). Therefore, hoverflies are important as biological control agents. Aphids are the more common prey used by hoverfly predatory species but some are able to feed on whiteflies, psyllids, scale insects and other homopterans, and lepidopteran and hymenopteran eggs, and thrips, or live in ant or bee nests (Schneider, 1969; Rojo *et al.*, 2003). They are also important as environmental quality indicators.

In orchards, they are between the first pollinators to appear in spring and they can be important for the control of aphid populations in the early season (Schneider, 1969; Rossi *et al.*, 2006). In Portugal, in the Oeste region, Santos (1999) detected *Sphaerophoria scripta* (L.), *Syrphus ribesii* (L.), *Eristalis arbutorum* (L.) and *Platycheirus albinamus* (Fab.) in pear and apple orchards.

This preliminary study aimed at identifying the species present in different habitats, in a periurban

ecosystem, Tapada da Ajuda, Lisbon (Portugal), and relating their present with flowers and prey availability.

MATERIAL AND METHODS

Sampling was performed weekly from 16th March to 31th May 2017. Hoverflies were collected in different habitats in Tapada da Ajuda: olive orchard, plum orchard where *Vicia faba* L. was sown between lines, adventitious herbaceous vegetation mainly Asteraceae species near Lagoa Branca, and, in the last fortnight of the study period, an Apiaceae small field at the opposite side of the olive orchard road (Figure 1). Adults were collected in all habitats, mainly with entomological net, but also with plastic vials and plastic sacs. In the plum orchard, immatures (eggs, larvae and pupae) were also collected in aphid colonies on fava bean plants and plum trees, from 30th March to 18th May. Sampling of immature hoverflies was performed observing 8 or 10 fava plants/inter-row, randomly chosen, in 8 inter-rows (total: 48 and 80 plants), and 3 or 5 plum trees/row, in 5 and 4 rows, respectively (total: 35 trees).



Figure 1 - Habitats sampled for hoverfly prospection in Tapada da Ajuda (38°42'27.5"N; 9°10'56.3"W, Lisbon, Portugal): A - plum orchard; B - herbaceous vegetation near Lagoa Branca; C - Apiaceae small field; D - olive orchard (adapted from http://www.isa.ulisboa.pt/files/site/pub/mapa_tapadadaajuda_2014.jpg).

In laboratory, immatures were reared until adult emergence (hoverfly or parasitoid), feeding them with aphid colonies mainly of *Aphis fabae* Scopoli, but also *Megoura viciae* Buckton.

Hoverfly adults were identified up to species using several identification keys (Coe, 1953; Gilbert, 1986; Speight, 2014; Ball and Morris, 2015). Hoverfly parasitoids were identified up to family/subfamily after Pitkin (2004) and Broad (2011).

For each habitat, species richness (S), Shannon-Wiener (H'), Simpson (D), dominance (1-D) and equitability (E) indexes were calculated:

$$H' = -\sum_{i=1}^S p_i \ln p_i \quad D = \frac{\sum_{i=1}^S n_i(n_i - 1)}{N(N - 1)} \quad E = \frac{-\sum_{i=1}^S (\frac{n_i}{N} \cdot \ln(\frac{n_i}{N}))}{\ln N}$$

being,

S – species richness – number of species found in the sample;

N – number of specimens in the sample;

pi – proportion of specimens of the species i (ni/N).

Species richness was estimated for all the studied habitats together, using the software SPECRICH developed by Hines (1996), according to Burnham and Overton (1979), taking into account the number of rare species detected (those with ≤ 6 specimens collected).

RESULTS

We collected 57 specimens, mainly as adults but, in the plum orchard, also some as immature. From those collected as larvae, two were parasitized, and in one pupa there was no emergence of adult hoverfly or parasitoid. Moreover, we obtained seven adult hoverflies from the hoverfly larvae we took when we collected aphid colonies to feed the immature we were rearing in the laboratory. In total, we obtained 64 adults from 12 species (Table 1; Figure 2), the majority belonging to Syrphinae. Eighteen of *Sphaerophoria* Le Peletier & Serville were only identified up to genus since they were female but they were considered as *S. scripta* (L.) for further analysis since it was the only species we identified using the males. *Episyrphus balteatus*

(De Geer) was the most abundant (16 in 64 – 25%), although *Sphaerophoria* sp. was dominant in the olive and the plum orchards and in the Apiaceae field (Table 1). Sampling dates with higher number of adults captured were 17th March, 20-21th April and 18th May. The small field of Apiaceae was the habitat with higher specific richness even though it was sampled only in the last fortnight of this study. Simpson's and equitability indexes were similar in olive orchard and Apiaceae field, and higher and lower, respectively, than in the plum orchard; in Lagoa Branca, the habitat with lower hoverfly diversity Simpson's index was the highest (Table 1).

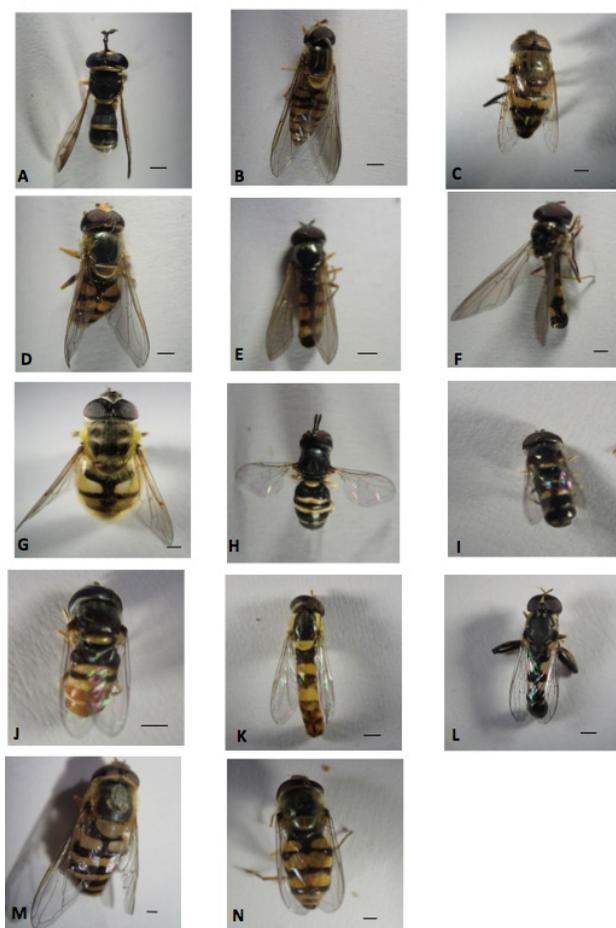


Figure 2 - Species of hoverfly found in Tapada da Ajuda (Lisbon, Portugal) between March and May 2017 in the sampled habitats: (A) - *Ceriana vespiformis* (Latreille); (B) - *Episyrphus balteatus* (De Geer); (C) - *Eristalinus taeniops* (Wiedemann); (D) - *Eupeodes corollae* (Fab.); (E) - *Melanostoma mellinum* (L.); (F) - *Melanostoma scalare* (Fab.); (G) - *Myathropa florea* (L.); (H, I, J) - *Paragus quadrifasciatus* Meigen; (K) - *Sphaerophoria scripta* (L.); (L) - *Syrphus pipiens* (L.); (M) - *Syrphus ribesii* (L.); and (N) - *Syrphus vitripennis* Meigen (bar – 1 mm).

Table 1 - Species and number of hoverflies collected and diversity indexes for the different studied habitats in Tapada da Ajuda (Lisbon, Portugal) (subfamilies criteria according to Young *et al.* (2016))

Species	Olive orchard	Apiaceae field	Lagoa Branca	Plum orchard	Total
Eristalinae					
<i>Ceriana vespiformis</i> (Latreille)	0	1	0	0	1
<i>Eristalinus taeniops</i> (Wiedemann)	0	1	0	0	1
<i>Myathropa florea</i> (L.)	0	1	0	0	1
<i>Syrirta pipiens</i> (L.)	1	5	0	0	6
Syrphinae					
<i>Episyrphus balteatus</i> (De Geer)	5	2	7	2	16
<i>Eupeodes corollae</i> (Fab.)	0	2	1	0	3
<i>Melanostoma mellinum</i> (L.)	2	0	0	1	3
<i>Melanostoma scalare</i> (Fab.)	2	0	0	0	2
<i>Paragus quadrifasciatus</i> Meigen	0	1	0	2	3
<i>Sphaerophoria scripta</i> (L.)	2	3	0	1	6
<i>Sphaerophoria</i> sp. (females)*	6	6	2	4	18
<i>Syrphus ribesii</i> (L.)	0	0	0	2	2
<i>Syrphus vitripennis</i> Meigen	0	0	0	2	2
Total	18	22	10	14	64
Diversity indexes					
species richness (S)	5	8	3	6	
Simpson (D)	0.26	0.21	0.49	0.15	
dominance (1- D)	0.74	0.79	0.51	0.85	
Shannon-Weiner (H')	1.36	1.70	0.80	1.67	
equitability (E)	0.85	0.82	0.73	0.93	

*It is not possible to identify up to the species females of the genus *Sphaerophoria*.

According to Burnham and Overton (1979), hoverfly' species richness in Tapada da Ajuda was estimated in 15 species.

In the plum orchard 15 larvae/pupae were observed in aphid colonies collected in fava (Figure 3) plants to feed the hoverflies immatures in laboratory. Seven hoverfly adults emerged as mentioned before, two pupae died, and six larvae/pupae were parasitized. *E. balteatus*, *S. scripta*, *Syrphus vitripennis* Meigen, *S. ribesii* and *Melanostoma mellinum* (L.) were identified from this material. From one of the parasitized pupae gregarious larval-pupal Pteromalidae (Hymenoptera: Chalcidoidea) parasitoids emerged and from the other five pupae we obtained solitary parasitoids of the subfamily Diplazontinae (Hymenoptera: Ichneumonoidea: Ichneumonidae) (Figure 4).



Figure 3 - Hoverfly larvae in aphid colonies in fava bean plants (A) and plum trees (B).

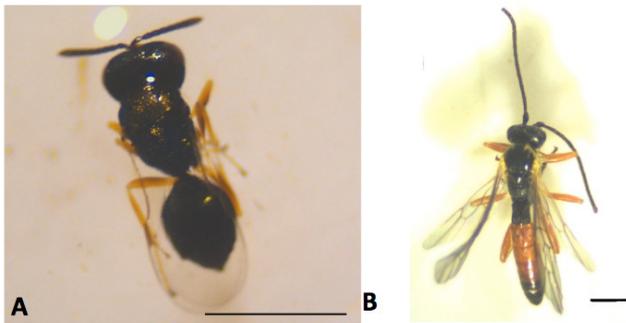


Figure 4 - Hoverfly's larval-pupal parasitoids detected in larvae collected in fava bean plants in the plum orchard, Tapada da Ajuda (Lisbon, Portugal): A - Pteromalidae gregarious parasitoid; B - Diplazontinae (Ichneumonidae) solitary parasitoid (bar – 1 mm).

Although these observations were performed in a very short period of time, the incidence of aphid on the fava plants increased over time reaching 100% of the sampled plants in 7th May; in plum trees it increased from the end of April to the beginning of May and decreased the following week (Figure 5). Hoverfly larvae and pupae increased over time on fava plants and on plum trees.

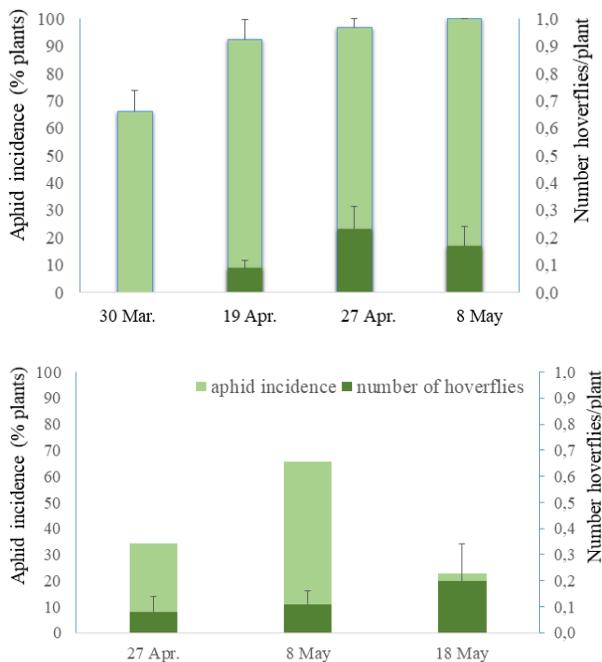


Figure 5 - Incidence of aphids (% sampled plants with aphid colonies) and number of hoverflies/plant in fava plants (A) and plum trees (B), in Tapada da Ajuda (Lisbon, Portugal).

DISCUSSION

As referred, we collected only 64 specimens belonging to 12 different species. The low number of specimens and species could be related to the short sampling period. It is important to note that the habitat with the highest species richness, the Apiaceae field, was only sampled in the last fortnight of the study. Besides, in the beginning of the sampling period, the olive orchard was covered with herbaceous plants, many of them were flowering and we were collecting a high number of hoverflies at that time. In the beginning of April these vegetation was cut and since then no hoverflies were collected in this habitat. If this cut was done later, after flowering, probably more adults would be captured in the olive orchard since these plants could have been important pollen sources for hoverfly adults in this ecosystem (Pinheiro *et al.*, 2013).

Spring of 2017 was very hot, especially April and May (IPMA, 2017a, b, c) but temperature was not a reason for capturing such a low number of Syrphidae. In fact, Santos (1999) found hoverflies until August in apple orchards in the Oeste region, although in small number, Pineda and Marcos-Garcia (2008) found hoverflies in greenhouses in Alicante until the middle of July and Hong and Hung (2010) verified that adult longevity and number of preyed aphids were more dependent on the prey species present than on the temperature, for the temperature range 26.6-29.9°C.

Sampling was mainly made in the 2nd half of the morning and afternoon. This fact could have affected the number of specimens collected since hoverflies fly mostly during the first hours of the morning, in sunny days (Pineda and Marcos-Garcia, 2008).

Nevertheless, the number of species detected was 80% (and three species inferior) of the estimated species richness for Tapada da Ajuda, based on the rare species found (species with six or less sampled specimens) even with the short sampling period.

The number and species richness in the different habitats seemed to be related to the floristic composition. Apiaceae field presented the highest diversity which is in accordance with previous studies

indicating that hoverflies prefer Apiaceae plants, for example, to Asteraceae, Fabaceae or Ranunculaceae (e.g. Tooker *et al.*, 2006; Sajjad and Saeed, 2010; Bertolaccini *et al.*, 2012; Wäckers and van Rijin, 2012).

In the plum orchard, despite the low floristic diversity and the reduced number of Apiaceae or Asteraceae plants present, the fava plants allowed a high hoverfly diversity that in meantime moved to plum trees, due to the abundance of prey (Colley and Luna, 2000), mainly *A. fabae*.

All the Eristalinae found in this study are saprophagous and all the Syrphinae are aphidophagous (Table 1) (Sommaggio, 1999; Ball and Morris, 2015). All the Syrphinae species are polyphagous in what it refers to the prey and to the host plant. Regarding the aphids reported as prey for the hoverflies present in the plum orchard, *E. balteatus* is referred as preying on *A. fabae* and *H. pruni*, in several crops, and on *M. viciae* and *M. persicae*, in laboratory; *Melanostoma mellinum* is referred as preying on *A. fabae*; *Paragus quadrifasciatus* Meigen on *A. fabae*, *H. pruni* and *M. persicae*, in several crops; *Sphaerophoria scripta* on *A. fabae*, *M. viciae*, *H. pruni* and *M. persicae*, in several crops;

Syrphus vitripennis on *A. fabae*, *H. pruni* and *M. persicae* and on a different species of the genus *Megoura*, in several crops (Rojo *et al.*, 2003). These results are in accordance with those of Bertolaccini *et al.* (2012) who verified that hoverflies feed on one or more than one aphid species present in the orchards.

Larval or pupal parasitism is not uncommon in hoverflies. For example, Jankowska (2004) found parasitism varying between 14.4% e 46.4% in aphidophagous larvae collected in field and reared until adult in laboratory. These authors identified parasitoids belonging to three Hymenoptera families, Ichneumonidae, Pteromalidae and Encyrtidae, being the majority Diplazontinae (Ichneumonidae), as in the present study. Yet, in some ecosystems Pteromalidae is dominant (Sommaggio *et al.*, 2014).

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