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Contribution to the phenological knowledge of *Aspilota*-group (Hymenoptera Braconidae Alysiinae) in Mediterranean landscapes

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ABSTRACT This work analyses the phenology of *Aspilota*-group in three Mediterranean Natural parks: Natural Park of La Font Roja, Natural Park of Las Lagunas de la Mata-Torrevieja and Natural Park of La Tinença de Benifassà. Samples were carried out from April 2004 to December 2007. In total, 820 specimens of 53 different species were collected and analysed. The results showed that there was a direct relationship between phenology and climatic conditions, as the highest abundances of *Aspilota* Förster, 1862 were observed when temperatures were between 18-22ºC and a few weeks after the rainy season. Phenological information at species level is also provided.

KEY WORDS Hymenoptera; Braconidae; *Aspilota*-group; Phenology; Mediterranean; Natural parks; Spain.

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INTRODUCTION

Braconidae is the second largest family of Hymenoptera Apocrita, belonging to the superfamily Ichneumonoidea with approximately 40,000 species described around the World. The majority of these species are primary parasitoids of immature stages of Lepidoptera, Coleoptera and Diptera (Sharkey, 1993).

The subfamily Alysiinae has a prominent position in terms of diversity within the Braconidae (Dolphin & Quicke, 2001), enclosing 1,500 species divided among 2 tribes: Alysiini and Dacnusini (Shenefelt, 1974). Alysiini interact with a wide variety of Cyclorrhapha hosts mainly in humid habitats and ephemeral substrata, laying their eggs in the host's larvae or eggs. Dacnusini, by contrast, are almost exclusively specialised on leaf and stem miners, such as Agromyzidae, Ephydridae and Chloropidae. Furthermore, Alysiini are distributed in all regions while Dacnusini are known only in the temperate and boreal regions of the Northern Hemisphere.

The *Aspilota*-group is rather well differentiated inside the Alysiini tribe (van Achterberg, 1988) with approximately 750 species described (Yu et al., 2011). This group includes the following genera: *Adelphenaldis* Fischer, 2003, *Aspilota* Förster, 1862, *Carinthilota* Fischer, 1975, *Dinostigm*a Fischer, 1966, *Dinotrema* Förster, 1862, *Eudinostigma* Tobias, 1986, *Leptotrema* van Achterberg, 1988, *Orthostigma* Ratzeburg, 1844, *Panerema* Förster 1862, *Pterusa* Fischer, 1958 and *Synaldis* Förster , 1862. However, this classification has been changing over the last decades. For instance, van Achterberg (1988) did not consider *Synaldis* as a genus and included their species within *Dinotrema* but Fischer (1993a;1993b), Belokobylskij (2002;

2004a; 2004b) and Tobias (2003a; 2003b; 2004a; 2004b; 2006) posteriorly published *Synaldis* as a distinctive genus due to the absence of the 2RS vein.

There are many faunal and diversity studies of Braconidae worldwide, for example in Brazil (Cirelli & Penteado-Dias, 2003; Scatolini & Penteado-Dias, 2003), Venezuela (Briceño et al., 2007; 2009) and the Iberian Peninsula (Andorra, Spain and Portugal), (Nieves & del Castillo, 1991; Pujade-Villar, 1996; Segade et al.,1997; Ros-Farré & Pujade-Villar, 1998; González et al., 2000; Martínez de Murguía et al., 2001; Tomé et al., 2001; Falcó-Garí et al., 2006). Nevertheless, the phenology of these species remains poorly investigated due to the lack of extensive monitoring studies. A few exceptions are Falcó-Garí et al. (2006), Peris-Felipo & Jiménez-Peydró (2011), Jiménez-Peydró & Peris-Felipo (2011) and Pérez-Rodríguez et al. (2013).The present study deals with data obtained from extensive researches on phenology and on the relationship between the *Aspilota*-group community and the environmental and climatic conditions present on three protected Mediterranean areas in Spain.

MATERIALS AND METHODS

Studied areas

The parks selected were Natural Park of La Font Roja (Font Roja), Natural Park of Las Lagunas de la Mata-Torrevieja (Torrevieja) and Natural Park of La Tinença de Benifassà (Tinença); all located within the Comunidad Valenciana and each with peculiar microclimate conditions. Climatic and orographic descriptions were given by Peris-Felipo & Jiménez-Peydró (2012).

Sampling protocol

The sampling period ranged from April 2004 to December 2007 and samples were taken with Malaise traps. Each area was weekly visited to be sampled with an entomological net and to replace the trap drop. Exemplars captured were preserved in 70% ethanol until final preparation.

Once separated, single specimens were determined by subfamily following the keys of Achterberg (1993) and only the Alysiinae were selected. Subsequently, the identification to genera was carried out according to Tobias keys (1986a; 1986b). Finally, species identification was done based on Fischer (1993b; 2003; 2008a; 2008b) and Tobias (1986a; 1986b) keys. The studied exemplars are now deposited with bar code labels in the Entomological Collection at the University of Valencia (Valencia, Spain; ENV).

Information about all climatic conditions was provided by AEMET (State agency of Metereology) with the exception of the one from Font Roja. Data about this area was taken from Bocairent station, as there is no AEMET station in Alcoi.

In the present study, the following simplifications of period extensions were adopted:

• Spring: period comprising between 23rd March and 22nd June.

• Summer: period comprising between 23rd June and 22nd September.

• Autumn: period comprising between 23rd September and 22nd December.

• Winter: period comprising between 23rd December and 22nd March.

RESULTS AND DISCUSSION

In total, 820 specimens belonging to 53 species of *Aspilota*-group were collected. The Natural Park with more described species was Tinença with 39, followed by Font Roja and Torrevieja with 23 and 21, respectively. Furthermore, the number of captures differed between areas, having collected 383 individuals in Tinença (49.08%), 257 in Torrevieja (63.03%) and 182 in Font Roja (65.93%). The most captured species in Font Roja was *Orthostigma laticeps* (Thomson, 1895) followed by *Synaldis lacessiva* Fischer, 1975 and *Dinotrema parapunctatum* (Fischer, 1976). However, *Dinotrema costulatum* (Thomson, 1895) was the most represented in Tinença, followed by *Synaldis* sp.2, *Dinotrema crassicostum* (Thomson, 1895), *Aspilota valenciensis* Fischer, 1996 and *Dinotrema castaneithorax* (Fischer, 1973). Finally, *Synaldis* sp.2, *Dinotrema lagunasense* Peris-Felipo, 2013 and *Aspilota procreata* Fischer, 1976 were the most dominant in Torrevieja.

The whole data (Fig. 1) showed that species belonging to *Aspilota*-group can be found throughout

the entire year.The highest abundance was found between April and September (spring and summer), identifying two peaks corresponding to spring-summer (March-July) and autumn (September-November).

The analysis of the Natural Park of La Font Roja (Fig. 2) demonstrated that there were quite more capture peaks. The activity period at this area was extended from April till late September (spring and summer), peaking at the end of May and with a lack of captures between December and April (winter and early spring).

However, Natural Park of La Tinença of Benifassà (Fig. 3) showed a different situation with two peaks of activity, the first between April and June (spring) and the second between September and November (autumn). The highest abundances were observed in May and June 2006, both with 18 specimens. Captures in the remaining months were very sporadic, being virtually absent during the winter.

Finally, two peaks of activity were determined in the Natural Park of Las Lagunas de La Mata-Torrevieja (Fig. 4), one between April and June (spring) and the other between October and December (autumn). The highest abundance was observed on April 2005 with 19 specimens and a third peak was observed in some years between December and March (winter). However, no specimens were ever captured between late July and early September.

The analysis of abundance (Figs. 2-4) clearly shows that the peaks appear at different periods on each site. Comparison between these peaks and climatic data (temperature and rainfall) was done by superimposing the first to the second.

It is possible to observe that in Font Roja (Fig. 5) the largest number of captures occurs between June and September after the spring rainfall and coinciding with temperate temperatures (15-25°C). By contrast, there are no significative captures during autumn and winter.

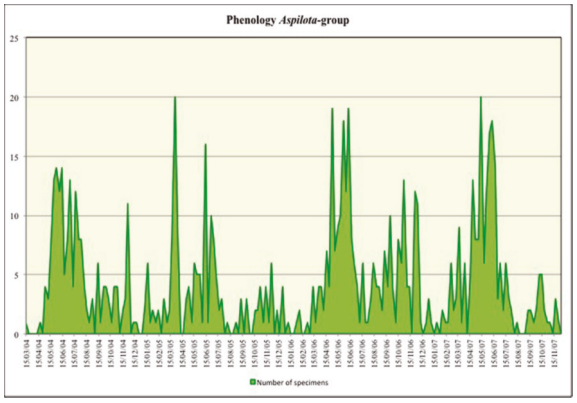
However, in Tinença (Fig. 6) the maximum peaks of abundance occur a few weeks after the rainy season and *Aspilota* populations seem to decrease till disappearing when temperatures exceed 20ºC (July-August). Therefore, the population seems to be affected by the presence and abundance of rainfall, probably due to their parasitoid relationship with leaf-miner insects, mainly from herbaceous.

In Torrevieja (Fig. 7) braconids are better captured when temperatures are temperate (15-20°C) and they disappear when temperatures rise.

All these considered, it is possible to check the relationships between the appearance of *Aspilota*-group and rain. Table 1 shows the phenology of each species per month, with most of the species being present in spring. However, there are species that appear in spring and autumn but not in warm periods such as *Aspilota procreata* Fischer, 1976, *Dinotrema enanum* Peris-Felipo, 2013, *Dinotrema fischerianum* Peris-Felipo, 2013, *Synaldis concolor* (Nees, 1812) and *Synaldis distractum* (Nees, 1834). Some other species appear during autumn and winter, e.g., *Dinotrema lagunasense* Peris-Felipo, 2013, *Dinotrema pareum* Peris-Felipo, 2013 and *Synaldis* sp.7 and many others appear in every season, such as *Aspilota propeminimam* Fischer, Tormos, Pardo et Asís, 2008, *Aspilota valenciensis* Fischer, 1996, *Dinotrema costulatum* (Thomson, 1895), *Dinotrema paquitae* Peris-Felipo, 2013, *Orthostigma laticeps* (Thomson, 1895), *Orthostigma maculipes* (Haliday, 1838), *Orthostigma pumilum* (Nees, 1834) or *Synaldis* sp.2. Finally, three species: *Dinotrema teresae* Peris-Felipo, 2013, *Orthostigma beyarslani* Fischer, 1995 and *Orthostigma sculpturatum* (Tobias, 1962), seem to be present only for a month.

Comparing the three different parks, it is possible to determine that the maximum peaks of abundance occur when temperature ranges oscillate between 18 and 22ºC. Similar observations were found in the Artikutza (Navarra, Spain) when studying the phenology of Alysiinae (Peris-Felipo et al., 2011) and in the Andorran Pyrenees (Falcó-Garí et al., 2006) while analyzing the Braconidae. Another fact to be highlighted is that maximum abundances are always present few weeks after the rainy periods. This is probably explained by tritrophic relationships between parasitoid-host-plant, as the rain promotes the growth of herbaceous whose leaves are mined by mining insects and consequently increases the activity of the Hymenoptera parasitoids.

In conclusion, this study was conducted to determine the phenology of the *Aspilota*-group. However, further studies are recommended in different areas to check the differences between *Aspilota* behaviors.



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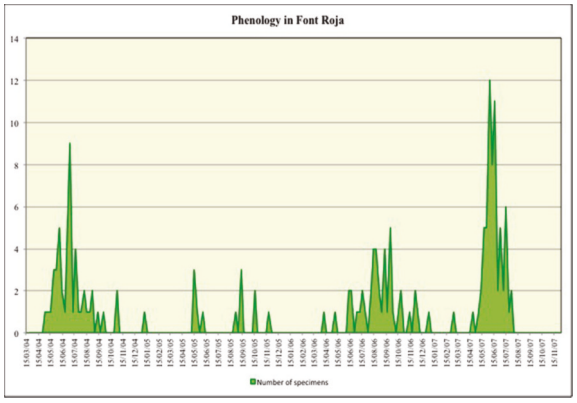

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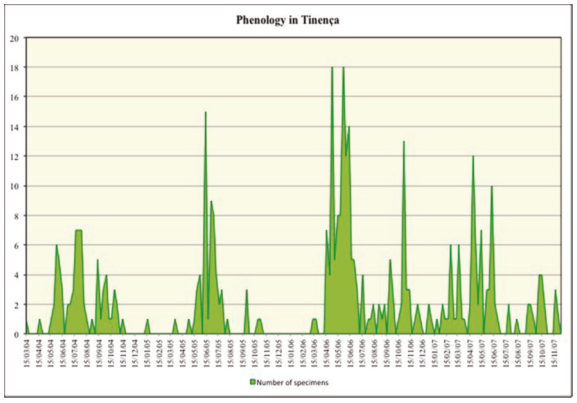

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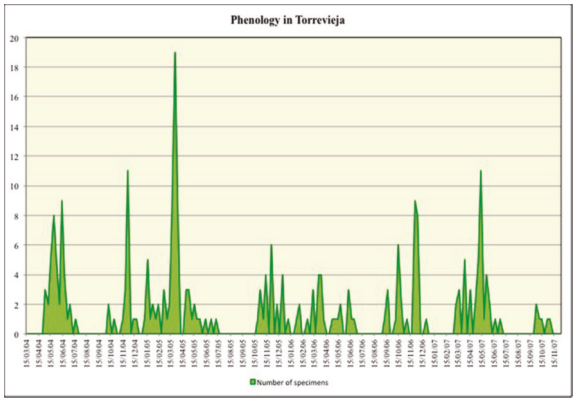

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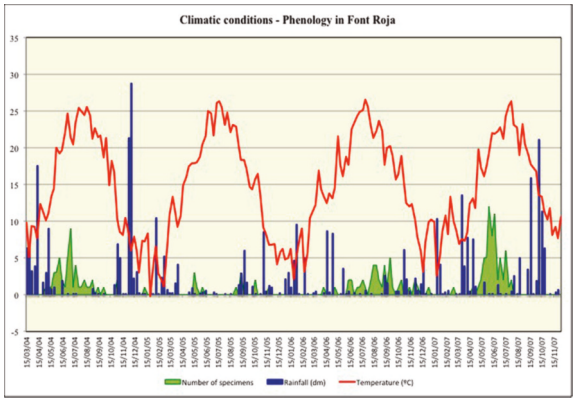

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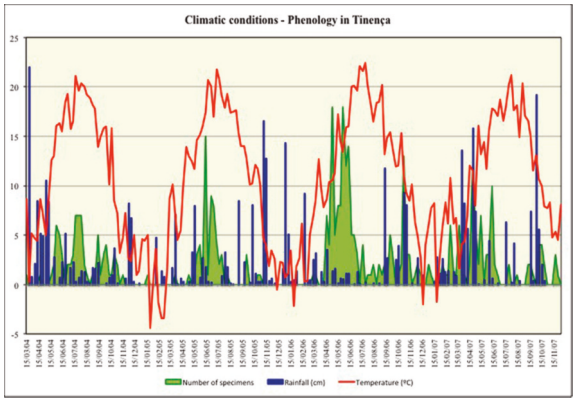

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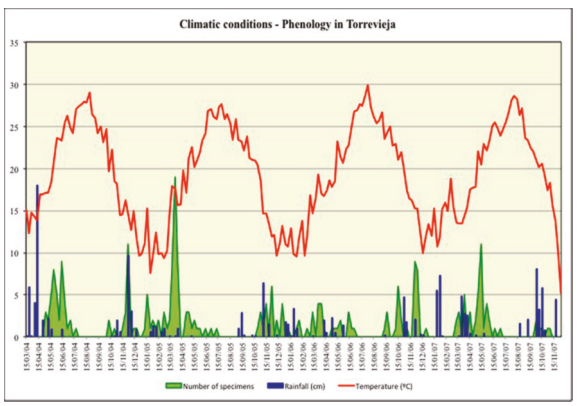

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Figure 1. Phenology of *Aspilota*-group.
Figure 2. Phenology of *Aspilota*-group in the Natural Park of Carrascal de La Font Roja.
Figure 3. Phenology of *Aspilota*-group in the Natural Park of Tinença de Benifassà.
Figure 4. Phenology of *Aspilota*-group in the Natural Park of las Lagunas de La Mata-Torrevieja.
Figure 5. Relationship between climatic conditions and phenology in the Natural Park of La Font Roja.
Figure 6. Relationship between climatic conditions and phenology in the Natural Park of La Tinença de Benifassà.
Figure 7. Relationship between climatic conditions and phenology in the Natural Park of Las Lagunas de La Mata-Torrevieja.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adelphenaldis maxfischeri						■	■					
Aspilota anaphoretica					■					■		
Aspilota delicata			■						■			
Aspilota flagimilis						■					■	
Aspilota insolita			■			■						
Aspilota procreata			■	■	■	■						■
Aspilota propedaemon			■		■	■		■				■
Aspilota propeminimam		■	■	■	■	■	■				■	
Aspilota valenciensis	■		■	■	■	■		■		■		
Aspilota sp1					■	■						
Aspilota sp2				■		■						
Dinotrema achterbergi		■				■				■	■	■
Dinotrema amparoae		■	■	■							■	
Dinotrema belokobylskiji										■		
Dinotrema benifassaense				■	■	■	■					
Dinotrema broadi	■	■			■		■			■	■	
Dinotrema castaneithorax		■		■	■	■		■	■	■		
Dinotrema costulatum	■	■	■	■	■	■	■		■	■	■	
Dinotrema crassicostum				■	■	■		■	■	■		
Dinotrema enanum				■	■							■
Dinotrema fischerianum				■	■							
Dinotrema jimenezi									■	■		
Dinotrema lagunasense	■	■	■	■							■	■
Dinotrema mareum					■		■					
Dinotrema munki					■					■		
Dinotrema pappi	■				■							
Dinotrema paquitae		■	■	■	■		■			■		
Dinotrema parapunctatum						■	■	■	■	■		
Dinotrema pareum	■	■	■	■						■	■	
Dinotrema pilarae	■											
Dinotrema robertoi							■	■	■			
Dinotrema teresae				■								
Dinotrema tinencaense						■	■	■				
Dinotrema torreviejaense				■	■							
Dinotrema vitobiasi				■	■							
Dinotrema zimmermannae				■		■	■			■	■	
Eudinostigma latistigma					■	■	■					
Orthostigma beyarslani					■							

Table 1. Monthly occurrence for each species.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Orthostigma laticeps	■		■	■	■	■	■	■	■	■		■
Orthostigma maculipes			■		■	■	■		■			
Orthostigma pumilum			■		■	■	■	■	■	■		
Orthostigma sculpturatum								■				
Synaldis concolor	■	■	■	■	■	■	■					
Synaldis distracta	■	■	■	■	■	■	■				■	
Synaldis lacessiva					■	■	■	■	■	■	■	
Synaldis sp1							■					
Synaldis sp2	■			■	■	■	■	■	■	■	■	■
Synaldis sp3							■				■	
Synaldis sp4						■	■	■	■	■		
Synaldis sp5		■			■	■	■					
Synaldis sp6					■	■			■	■		
Synaldis sp7		■	■									

Table 1 (continued). Monthly occurrence for each species.

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