

Remarks on the biology of *Dinera ferina* (Diptera Tachinidae) as parasitoid of the two Italian *Platycerus* species (Coleoptera Lucanidae)

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Abstract

Improving the data of the Italian host list of Tachinidae, *Dinera ferina* (Fallen) is confirmed to be a parasitoid of larvae of the two Italian *Platycerus* species, *Platycerus caprea* (De Geer) and *Platycerus caraboides* (L.) (Coleoptera Lucanidae). In 2015, 2016 and 2017, larvae, puparia and adults of the tachinid fly were studied in field, semi-field and laboratory conditions. The mature larva of the parasitoid was almost as big as its host, and showed the posterior spiracles from the host cuticle. The emergence from the host took only a few seconds. *Platycerus* pupae were not involved in *D. ferina* parasitism. Pupation occurred outside the host remains, from a third instar *Platycerus* larva. In semi-field and laboratory conditions, pupal duration was recorded to be 23.8 ± 7.0 (mean \pm S.D.) days long. The presence of soft wood and frass near the puparium seemed to be necessary for the freshly emerged adult of *D. ferina*, to leave the wood habitat. Their adults were observed mainly in May, with few individuals found in April, June or September. In the field, the parasitism rate on *P. caraboides* amounted to 23.7%, with differences among collecting provinces and sites.

Key words: *Platycerus caprea*, *Platycerus caraboides*, saproxylic, larva, host.

Introduction

Tachinid flies (Diptera Tachinidae) live in nearly all terrestrial environments, as deserts, forests, grasslands, mountains and tundra, where adults feed on nectar and other plant exudates and products (Stireman *et al.*, 2006). About 8500 species of tachinid flies are described worldwide (O'Hara, 2013), and more than 1600 in the Palaearctic Region (Tschorsnig and Richter, 1998). In Italy, 640 species are recorded (Cerretti, 2010a). Despite the occurrence of polyphagous and monophagous species, they usually are oligophagous; the larvae are endoparasitoids and have a wide host range within the phylum Arthropoda (Mellini, 1991; Stireman *et al.*, 2006; Cerretti *et al.*, 2010; Dindo, 2011; Tschorsnig, 2017).

In the tribe Dexiini, the female lays its eggs or larvae into external holes of the host galleries (Mellini, 1991; Stireman *et al.*, 2006; Cerretti *et al.*, 2010) and the larvae actively search for their hosts through chemosensory cues (indirect 'searchers' of Stireman *et al.*, 2006). It allows the parasitism of hosts living in 'hidden places' (i.e., underground or in the wood). Particularly, in the tribe Dexiini several species are parasitoids of saproxylic beetle larvae (Coleoptera), including Scarabaeidae, Lucanidae, Buprestidae, Cerambycidae, Curculionidae and Tenebrionidae, as well as larvae of ground beetles (Carabidae) (Zhang and Shima, 2006; Cerretti *et al.*, 2010; Tschorsnig, 2017). In the genus *Dinera* Robineau-Desvoidy, 21 species are described for the Palaearctic and Oriental Regions (Zhang and Shima, 2006; Zhang and Fu, 2012), four of them occurring in Europe: *Dinera carinifrons* (Fallen), *Dinera ferina* (Fallen), *Dinera fuscata occidentalis* Ziegler, and *Dinera griseascens* (Fallen) (Tschorsnig *et al.*, 2004; Pape *et al.*, 2015; Ziegler *et al.*, 2016).

The aim of the present study is to report some cases of

parasitism by the tachinid fly *D. ferina* of the larvae of the two Italian *Platycerus* species, *Platycerus caprea* (De Geer) and *Platycerus caraboides* (L.), and to report some ecological notes on the parasitoid.

Materials and methods

The study was conducted in 2015, 2016 and 2017, in field, semi-field and laboratory conditions. In the field, during collection of *Platycerus* individuals in three provinces of northern Italy where they are present, Bergamo, Pavia, and Piacenza (Bartolozzi and Maggini, 2007; Scaccini, 2018, and personal observation), larvae and puparia of their parasitoid were collected, and an adult observed. *P. caprea* and *P. caraboides* were collected directly from the deadwood; findings of suitable logs were aided by the presence of their oviposition scars (Scaccini, 2016), also because *Platycerus* are not very common beetles. *P. caprea* and *P. caraboides* were reared in semi-field condition in boxes, kept separated according to the origin of the specimens. Furthermore, some larvae and pupae of the two Italian *Platycerus* species were reared in a laboratory mimicking natural temperature (23-25 °C in summer, 7-9 °C in winter). The pupal duration and the adults' appearance period were recorded. Beetles have been identified by using identification keys (cf. Hürka, 1975; Franciscolo, 1997; Scaccini, 2015). Tachinid identification was performed on adults by using the identification keys of Tschorsnig and Herting (1994; translated by Rayner and Raper, 2001) and Cerretti (2010a; 2010b). Parasitoids are stored in the author's collection in Zelo Buon Persico (Lodi), and two adults in the Florence Museum (Museo di Storia Naturale dell'Università degli Studi di Firenze, division of Zoology 'La Specola').

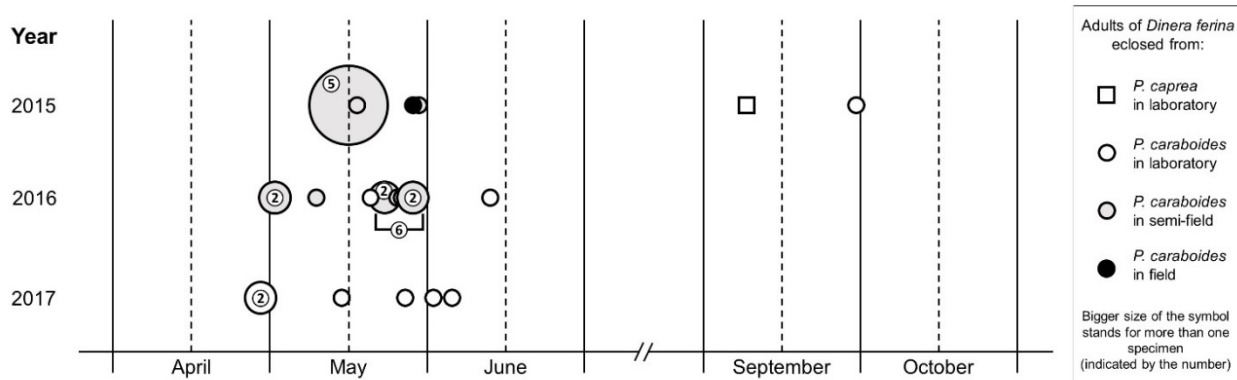


Figure 1. Adults' appearance of *D. ferina* in field, semi-field and laboratory conditions, 2015-2017.

Results and discussion

P. caprea and *P. caraboides* are herewith confirmed hosts of *D. ferina*, improving the data of the Italian host list of Tachinidae (Cerretti and Tschorsnig, 2010). Only one case of parasitism was recorded for a larva of *P. caprea* (surroundings of Brallo di Pregola, Pavia province, 1160 m a.s.l., August 17, 2015), while the others concerned *P. caraboides* larvae. Parasitoids never emerged from *Platycerus* pupae.

D. ferina is distributed in Europe, and in Russia in East Siberia and the Transcaucasus (Zhang and Shima, 2006). The current host list of *D. ferina* includes larvae of the following saproxylic beetle species: *Sinodendron cylindricum* (L.), *Dorcus parallelipipedus* (L.) (Lucanidae), *Helops coeruleus* (L.) (Tenebrionidae), and *Drymochares cylindraceus* (Fairmaire) (Cerambycidae) (e.g. Didier, 1937; van Emden, 1950; Herting, 1960; Campadelli, 1989; Hidalgo-Fontiveros, 2014; Tschorsnig, 2017). Grandi (1951) also quoted that the larvae of *P. caraboides* could be parasitized by the tachinid fly *D. ferina*, although the observation is not effective because the two Italian *Platycerus* species were not distinct up to 1956 (cf. Franciscolo, 1997).

D. ferina inhabits forest edges, deforested areas, and meadows, and adults are often observed on flowers (Campadelli, 1989; Tschorsnig and Herting, 1994). In Europe, *Dinera* species are observed from lowlands and medium elevations, up to the high mountains (e.g. Tschorsnig *et al.*, 2003; Lutovinovas *et al.*, 2013; Pohjoismäki, 2013; Ziegler *et al.*, 2016).

Adults are recorded from early June to the end of September, with a peak from the end of June to mid-August (Campadelli, 1989; Tschorsnig and Herting, 1994; Lutovinovas *et al.*, 2013). It is considered a seasonal species in a field study in Germany (Pohjoismäki, 2013), and probably has only one generation per year (Tschorsnig and Herting, 1994). In the present study, adults of *D. ferina* were observed mainly in May, while few individuals in April, June or September (figure 1). The ovularviposition of *D. ferina* can occur from spring to late summer, possibly in external holes of the host galleries on deadwood as hypothesized by Campadelli (1989). The female could be attracted by deadwood and locate the host by the presence of its frass, which can act as kairomones as reported for different tachinid species

(e.g. Vinson, 1976; Roth *et al.*, 1978; Clement *et al.*, 1986; David *et al.*, 1988; Vet and Dicke, 1992; Tanaka *et al.*, 2001; Stireman *et al.*, 2006; Wilson and Woods, 2015). The first instar larvae actively search for the hosts in the deadwood, and develop inside them up to the first winter, when they enter diapause. The hibernation in tachinids takes place at the pupal stage, or in first- or early second instar larva (Tschorsnig and Richter, 1998), while there are some cases of hibernation taken by the third instar (Cerretti and Mei, 2001).

D. ferina adults emerged from third instar larvae of *Platycerus*, and in at least two cases the second larval instar was already parasitized before the collection. A mature larva, as big as the host, shows the prominent posterior spiracles from the thorax of the host, near a leg (figure 2A), in the same position indicated by Campadelli (1989) in *S. cylindricum* larvae. Pupation of *D. ferina* occurred outside the host remains (figure 2B), and the emergence from the host lasted a few seconds. Furthermore, in two cases, the emerged larvae were observed to wander in the pabulum for one and four days, respectively. It could be possible that the larva actively searches for a place to pupate, or prepares a way out for the adult as done by the Dexiinae *Billaea irrorata* (Meigen) (Pulkkinen and Yang, 1984). Despite it is not clear how the adult of *D. ferina* leaves the wood habitat (Campadelli, 1989), in several cases puparia were found in soft wood places, with a lot of frass, often near the wood surface (figure 2B).

Morphologically, the puparium of *D. ferina* belongs to the *D. carinifrons* and *Billaea* spp. group (Ziegler, 1998; Ziegler *et al.*, 2016). Pupal stage lasted 23.8 ± 7.0 (mean \pm S.D.) days, ranging from 17 to 36 days ($n = 6$). The adult (figure 2C-E) left the deadwood habitat right after the emergence.

Parasitism rates for *P. caraboides* are reported in table 1, arranged by province. Notably, Campadelli (1989) reported a parasitism rate of 15.6% ($n = 96$ *S. cylindricum* larvae), considering it low, probably due to the difficulty for the parasitoid to reach the host in deadwood. Indeed, the abundance of other parasitoids (Hymenoptera) is recorded to be higher in snugs than in fallen logs, possibly due to the presence of the ground or the adjacent vegetation, which have a negative influence on the accessibility of fallen logs (Ulyshen *et al.*, 2011). The Italian *Platycerus* species prefer fallen logs



Figure 2. *D. ferina*. **A)** Parasitism of *P. caraboides* larva: protruded posterior spiracles are visible on the host prothorax (arrow); **B)** Puparium in field, with remains of the host (arrow), and a lot of frass in a soft wood; **C)** Adult habitus (female), about two hours after the eclosion; **D)** Right wing; **E)** Head (male).
(In colour at www.bulletinofinsectology.org)

Table 1. *P. caraboides*: parasitism rates and collecting data.

Municipality (province)	Elevation (m a.s.l.)	n of <i>D. ferina</i> (adults)	n of <i>P. caraboides</i> larvae (second and third instars)	Parasitism rate by province (%)
Bettola (Piacenza)	790	1	31	Piacenza 20.8
Bobbio (Piacenza)	455	1	7	
Farini (Piacenza)	725	4	12	
Farini (Piacenza), close to Pradovera	855	2	4	
Gropparello (Piacenza)	725	2	5	
Ponte dell'Olio (Piacenza)	585	2	7	
Rivergaro (Piacenza)	460	3	6	
Lenna (Bergamo)	630	1	8	Bergamo 28.6
Piazzatorre (Bergamo)	1000	5	17	
Piazzolo (Bergamo), place 1	750	2	7	
Piazzolo (Bergamo), place 2	760	2	2	
Piazzolo (Bergamo), place 3	840	2	8	
Total	from 455 to 1000	27	114	23.7

rather than standing ones (Scaccini, 2016), however the total parasitism rate (calculated considering living second and third instar larvae, n = 114) was higher (23.7%) than that observed by Campadelli (1989) on *S. cylindricum*. This can be explained by a higher susceptibility to parasitism by *Platycerus* species. Some differences recorded between Bergamo and Piacenza provinces need to be confirmed by further investigations (table 1).

Conclusions

The host/parasitoid relationship between *D. ferina* and the two Italian *Platycerus* species is here confirmed. Emergence of adults of *D. ferina* occurred outside the remains of third instar larvae of the hosts, and in at least two cases the host was parasitized before being a third instar larva. Adults of the parasitoid were observed mainly in May, but also in April, June and September, and parasitism rates varied among sites. Saproxylic organisms often have strict relationship with other species, and improving our knowledge on these relations can act as key issue to better understand the dynamics of the saproxylic community.

Acknowledgements

The author is grateful to Pierfilippo Cerretti for the careful revision and the confirmation of tachinid identification, and to Andrea Battisti and the three anonymous reviewers for revision. The author would like to thank Mauro Gori for kind advices provided before writing the manuscript.

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Received August 10, 2017. Accepted December 1, 2017.