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RECORDS OF ASILIDAE AND MUSCIDAE (DIPTERA) AS PREDATORS OF *PLATYCERUS CARABOIDES* AND *PLATYCERUS CAPREA* (COLEOPTERA LUCANIDAE) LARVAE IN DEADWOOD IN NORTHERN ITALY

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Scaccini D. – Records of Asilidae and Muscidae (Diptera) as predators of *Platycerus caraboides* and *Platycerus caprea* (Coleoptera Lucanidae) larvae in deadwood in northern Italy.

The present paper reports cases of predation on two Italian species of stag beetles, *Platycerus caprea* and *Platycerus caraboides*, by saproxylic Diptera of which preys were seldom reported or unknown in the literature. Resulting from eight years of collections in many sites in northern Italy, the robber flies *Laphria meridionalis* and *Choerades* sp. eclosed in rearing boxes of *P. caraboides*, and the muscid fly *Phaonia palpata* emerged from deadwood inhabited by both *Platycerus* species. These Diptera developed in deadwood of broadleaves species, where they were uncommon predators of *Platycerus* immature stages. Predator-prey interactions between Asilidae and Muscidae larvae and *Platycerus* improve the knowledge on the community of these species with hidden habits in the saproxylic scene.

KEY WORDS: saproxylic Diptera, robber fly, muscid fly, stag beetles, forest, predator-prey interaction, larva

INTRODUCTION

Saproxylic insects are organisms that depend on dying wood or deadwood during some parts of their life cycle, and are mainly composed of beetles, gnats, flies, termites, wasps, ants, bees and, to a lesser extent, of other taxa (STOKLAND *et al.*, 2012). Despite being poorly studied compared to other groups, about half of all Diptera families contains saproxylic species (at least 75 families of 157), including many predators or parasitoids of other saproxylic organisms (ULYSHEN, 2018). Predators of saproxylic insects belong to beetles (Cleridae, Elateridae, Histeridae, Monotomidae) and to flies (Asilidae, Dolichopodidae, Muscidae, Xylophagidae; STOKLAND *et al.*, 2012). Their main food sources are immature stages of detritivorous and fungivorous insects like bees, moths or beetles (STOKLAND *et al.*, 2012; ULYSHEN, 2018). In order to aid the predatory activity, their larvae evolved specialized structures such as strong tubercles for the movement in wood tunnels and body shape (KRIVOSHEINA, 2006; STOKLAND *et al.*, 2012).

During the larval stage, stag beetles (Coleoptera Lucanidae) feed on deadwood material colonized by fungi and other microorganisms (TANAHASHI *et al.*, 2009). Many species are bioindicators of forest integrity and are threatened by habitat loss, climate change, over-exploitation and intensive management of wood (e.g., BARDIANI *et al.*, 2017; HUANG, 2018). Two of the nine stag beetles species present in Italy belong to the genus *Platycerus* Geoffroy, 1762, which are relatively small (10–15 mm long) and bright beetles distributed in hill and mountain areas across the Italian Peninsula (FRANCISCOLO,

1997; BARTOLOZZI & MAGGINI, 2007; BARTOLOZZI *et al.*, 2016). Both *Platycerus caprea* (De Geer, 1774) and *Platycerus caraboides* (Linnaeus, 1758) are listed as ‘Least Concern’ in the Red List of the International Union for Conservation of Nature (CARPANETO *et al.*, 2015) and they are not common species in many areas (e.g., BARTOLOZZI *et al.*, 2016; BEZBORODOV, 2016; ALEKSEEV, 2018; BARTOLOZZI & CIANFANELLI, 2018; BEKCHIEV *et al.*, 2018). Their status triggers a lack of knowledge mainly on different aspects on their biology as regarding the relation with other saproxylic organisms like predators and parasitoids (FRANCISCOLO, 1997; SCACCINI, 2018a). The study of these relations is necessary to better understand the complex food web of saproxylic species (STOKLAND *et al.*, 2012), where predators compose an important portion of the system (ULYSHEN, 2018).

The aim of this paper is to report unusual cases of predatory interaction between three Diptera species, two Asilidae and one Muscidae, and the two Italian *Platycerus* species, resulting from collection of these stag beetles in different areas in northern Italy during eight years of surveys. These observations add data on the predator-prey relationship between saproxylic species not frequently collected in deadwood habitats.

MATERIALS AND METHODS

From 2012 to 2019, about 150 *P. caraboides* (from 27 sites) and 50 *P. caprea* (five sites) larvae were collected in deadwood in different forest areas in northern Italy, from Bergamo, Brescia, Padua,

Pavia, Piacenza, Lecco, Savona and Vicenza provinces (SCACCINI & ULIANA, 2017; SCACCINI, 2018a,b, and unpublished data). Deadwood sampling was performed on hills and mountains, and suitable logs were often detected by the presence of oviposition scars left by *Platycerus* females on the wood surface (SCACCINI, 2016). Deadwood in which insects were found was often moist and soft. Collected wood was manually opened to search for specimens inside; insects found therein were put in rearing plastic boxes (70 x 40 x 30 (h) cm, or 35 x 25 x 23 (h) cm) with the collected deadwood, and kept in semi-field conditions separated by collection site. Possible prey insects other than stag beetles, like insects having similar size to *Platycerus* third instar larvae, were not found in the logs considered in this study. A periodic check of rearing boxes permitted finding freshly eclosed Diptera and *Platycerus* adults. Collected *Platycerus* larvae and eclosed adults were identified following FRANCI-SCOLO (1997) and BALLERIO *et al.* (2014). Species identification of Diptera was performed on adults by Guy Tomasovic and Verner Michelsen – specialists of Asilidae and Muscidae, respectively –, except for a robber fly that was identified on adult remains following the key by VAN DER BROEK & SCHULTEN (2017).

ACRONYMS AND ABBREVIATIONS

Acronyms of collections:

DSC = Collection Davide Scaccini, Zelo Buon Persico, Lodi (Italy);

GTC = Collection Guy Tomasovic, University of Gembloux, Liège (Belgium).

Collection data: ♀ = female; ♂ = male; dm. = deadwood diameter (mean ± st. dev.); Dw. = deadwood details; Emer. = emerged; fac. = facing; le. = deadwood length (mean ± st. dev.); m = meters above sea level.

RESULTS

In only four occasions (less than 15% of the collection sites), three robber flies (Asilidae) belonging to two species and a muscid fly (Muscidae) eclosed from deadwood hosting *P. caraboides* larvae. Among robber flies, in March 2019 old remains of a *Choerades* sp. male were found in a rearing box of *P. caraboides* collected in Bergamo province, but data on reared larvae are not available. Additionally, two specimens of Muscidae (20% of the collection sites) also eclosed from deadwood colonized by *P. caprea* larvae. Collection data and specimens details are reported below.

Laphria meridionalis Mulsant & Revelière, 1860 (Diptera Asilidae)

Italy (2 specimens): Lombardy, Bergamo province, 'Località Forcella', between Piazzolo and Piazzatorre municipalities (45°58'56.4" N 9°40'53.2" E, 1023 m, fac. N), 1 ♀ (GTC; Fig. I), 19.VIII.2016 (cf. larva), D. Scaccini *legit.* Dw.: 8 *Fraxinus excelsior* L. logs, dm. 34.04 ± 7.04 mm, le. 553.75 ± 391.66 mm, with 4 *P. caraboides* third instar larvae and many oviposition scars on the surface. Emer.: 01.VI.2017. Of the 4 *P. caraboides* larvae, only 2 reached the adult stage.

Lombardy, Bergamo province, Piazzolo municipality (45°58'22.6" N 9°40'33.8" E, 897 m, fac. S/W), 1 ♀ (DSC), 15.VI.2019 (pupa), D. Scaccini *legit.* Dw.: *Fagus sylvatica* L. log, dm. 48.0 mm, le. 400.0 mm, with 3 *P. caraboides* third instar larvae and many oviposition scars on the surface. Emer.: 28.VI.2019.

Distribution: French mainland and Corse, Italy mainland (SÉGUY, 1927; CONTINI *et al.*, 1995; TOMASOVIC, 2003; GELLER-GRIMM, 2015).

Phaonia palpata (Stein, 1897) (Diptera Muscidae)

Italy (3 specimens): Lombardy, Bergamo province, surroundings of Lenna (45°55'54.95" N 9°40'09.83" E, 493 m, fac. W), 1 ♀ (DSC; Fig. II), 30.X.2016, D. Scaccini *legit.* Dw.: many *Tilia* sp., and *Acer* sp. logs, dm. 30.40 ± 7.29 mm, le. 633.33 ± 663.95 mm. With various *P. caraboides* larvae inside and oviposition scars on the surface of some woods. Emer.: 28.IV.2017.

Lombardy, Bergamo province, Roncobello (45°57'07.9" N 9°44'54.6" E, 1116 m, fac. N), 1 ♂ + 1 ♀ (DSC), 30.XII.2018, D. Scaccini *legit.* Dw.: *Fagus sylvatica* log, dm. 88.0 mm, le. 700.0 mm, with 2 *P. caprea* third instar larvae and many oviposition scars on the surface. Emer.: 20.IV.2019.

Distribution: Throughout Europe, also known from Turkey, Armenia, China and Taiwan (cf. PONT, 2018).

DISCUSSION

Compared to beetles, the habits of saproxylic flies remain poorly investigated. However, in the saproxylic insect assemblages Diptera are particularly diverse, more abundant and rich in species than Coleoptera (ULYSHEN, 2018). Improving the knowledge of predator-prey interaction in deadwood for uncommon species, this study underlines a feasible predation of *Platycerus* larvae by two species of Asilidae and one of Muscidae.

Fig. I – *Laphria meridionalis*, female. Dorsal view (1); dorso-lateral view (2); head, dorso-lateral view (3).

Fig. II – *Phaonia palpata*, female. Dorsal view (1); lateral view (2); head, frontal view (3). Photos credit: M. Mei.

However, the eclosion of these flies was observed only in a few occasions possibly due to their rarity or – more likely – *Platycerus* species are not selectively predated by the flies.

Predator flies often have unknown habits, especially for larvae living in deadwood. Robber flies larvae belonging to the subfamily Laphriinae (to which the genera *Choerades* and *Laphria* belong) live in deadwood galleries made by other insects (cf. VAN DER BROEK & SCHULTEN, 2017; WOLFF *et al.*, 2018). Previous records of *L. meridionalis* only showed the association with wood galleries of the jewel beetle *Lamprodila mirifica* (Mulsant, 1855) (Coleoptera Buprestidae) (SÉGUY, 1927; HELLRIGL, 1972). The association of *L. meridionalis* larvae is here reported for the first time with immature stages of *P. caraboides*, a stag beetle inhabiting rotting wood of different plant species. In particular, *L. meridionalis* specimens were found emerging from *Fagus sylvatica* and *Fraxinus excelsior* logs, known host plant genera for *P. caraboides* (KLAUSNITZER & SPRECHER-UEBERSAX, 2008; SCACCINI, 2018b). In semi-field conditions, the two females of *L. meridionalis* emerged from deadwood in June, showing a flight period similar to other *Laphria* species as outlined by VAN DER BROEK & SCHULTEN (2017) and WOLFF *et al.* (2018).

Muscidae are other known predators in rotting wood, and *Phaonia* larvae predate saproxylic and mycobiont organisms, attacking insect larvae with a soft integument (KRIVOSHEINA, 2013a,b). *Phaonia palpata* has been recorded to co-occur with *Elephantomyia edwardsi* Lackschewitz, 1932 (Diptera Limoniidae) and it was found in galleries made by Clusiidae (Diptera) larvae (KRIVOSHEINA, 2013b), but no more information is available on their prey. The association with the stag beetles *P. caprea* and *P. caraboides* here reported adds data on the preys of *P. palpata* in the deadwood environment. The known larval biotope of *P. palpata* is decaying wood of deciduous trees and wood mold in dead trees. In wooded and hilly areas, this species develops in deadwood of *Betula*, *Corylus*, *Fagus*, *Quercus*, *Salix* and *Ulmus*, and larvae were also collected from the moss growing on a *Sambucus* trunk (cf. SKIDMORE, 1987; KRIVOSHEINA, 2013a,b); the presence of *P. palpata* is here confirmed in rotting wood of beech, linden and maple. The eclosion of the three adults found in this study occurred in April in semi-field conditions, while in northern Europe it was reported in June (KRIVOSHEINA, 2013b), July and August (EMLEY, 1992; ZIELKE & BAÑAR, 2017; 2018), with a population peak in August–early September, thereby suggesting a second brood of adults (SKIDMORE, 1985).

Among arthropods, stag beetle immature stages are predated by other insects like ants (Hymenoptera Formicidae) or click beetles larvae (Coleoptera Elateridae) and parasitized by Diptera and Hymenoptera (PAWŁOWSKI, 1961; FRANCISCOLO, 1997; TSCHORSNIG, 2017; SCACCINI, 2018a). Besides, also other taxa may habitually or occasionally feed on stag beetle larvae as they do on other saproxylic beetle species (BRIN & BOUGET, 2018). Predator-prey interactions of

Asilidae and Muscidae larvae on *Platycerus* show that these aspects on the biology of uncommon prey species are still poorly understood, and improves the knowledge on the community of these saproxylic species.

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