Landscape management for functional biodiversity
IOBC-WPRS Bulletin Vol. 143, 2019
pp. 41-45

Flower selection of *Xylocopa violacea*: aromatic and ornamental plants as resources in a botanic garden

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Abstract: We assessed the interactions between aromatic and ornamentals plants and local pollinators in a botanic garden. We focused our attention on a frequent solitary bee, *Xylocopa violacea*, that thanks to its large size and its feeding preferences can visit many types of flowers. By conducting linear walking transects, we recorded all flower visits by bees, highlighting those of *X. violacea*. We analysed bee preferences in terms of plant family, plant origin or flower morphology. We also identified plant species that were visited by *X. violacea* together with other foraging bees. Results indicated that *X. violacea* selectively visits flowering plant species at the botanic garden, preferring Lamiaceae and bilabiate flower types on which legitimate or illegitimate visits can be performed. Other bee species do concurrently visit the same plants, and in the future studies on competition, resource exploitation and pollination success will be addressed.

Key words: plant-pollinator interaction, flower characteristics, aromatic, ornamentals

Introduction

Botanic gardens are very important for the scientific role they play and also for the social and recreational service they provide, especially considering the recent development of global urbanization. Together with natural and semi-natural areas, they can contribute to the maintenance of bee biodiversity, while serving as long-term sites for the evaluation of bee-flower interactions (Giovanetti et al., 2007). Botanic gardens offer a wide variety of flowers in terms of plant family, geographic origin and floral traits and offers the opportunity to study flower preferences of generalist bee species.

Xylocopa violacea is a solitary bee, known for its ability to forage on a wide range of flower types (Vicidomini, 2006) and, therefore, it could be expected to visit many of the aromatic and ornamental species present in a botanic garden. Moreover, *X. violacea* adopts two different nectar collection strategies, depending on the morphological characteristics of the flower (Vicidomini, 2004). A first strategy is the so-called legitimate visit: *X. violacea* feeds while landing on the front parts of the flower and accesses the nectar transferring pollen to the stamens. A second way is an illegitimate visit, accomplished by accessing the flower from behind and perforating the corolla. This strategy is frequently used on flowers with a long and narrow corolla. Illegitimate visits, or thefts, are terms indicating that the insect manages to overcome natural constraints while accessing the nectar reward, but not performing the expected pollination service (Rojas-Nossa et al., 2016; Vicidomini, 2006).

We investigated foraging preferences of *X. violacea* among the aromatic and ornamental flowering plant species in a botanic garden. We also verified the concurrent presence of other pollinators on the same plants and compared their frequency to that of *X. violacea*.

Material and methods

Study site

G. E. Ghirardi's botanic garden is located in Toscolano-Maderno on the Lake of Garda (Northern Italy), occupying an area of about 10,000 m^2; it was established in 1964 for cultivation and preservation of officinal species with pharmaceutical properties. Today it is managed by the University of Milan for research and outreach activities. The plant heritage currently includes more than 400 taxa from all the regions of the world. The local climate is mild, generally warm and classified by the Köppen-Geiger system as continental temperate, with hot summers. About 850 mm of precipitation falls annually; the hottest months are July and August with respective mean daily maximum temperatures of 28 °C and 29 °C (Soldati and Marchetti, 2017).

Monitoring

We recorded interactions of *X. violacea* females with flowers during linear walking transects. The phenological state of botanical species along the transects were assessed at fortnightly intervals during three flowering seasons (March-September, 2016; 2017; 2018). Presence of other foraging bees were recorded as well. Records on bee-flower interaction included a list of visited plant species, as well as the strategy adopted to collect nectar. We also identified, at the lowest-possible taxon level, the other bees visiting the same flowers as *X. violacea*. We photographed bee visits for additional species validation and double-checking the consistency of the dataset.

Data analyses

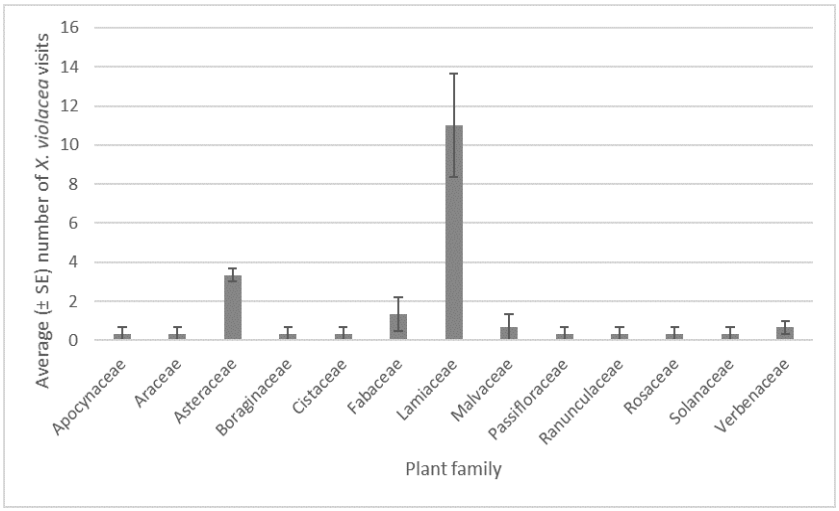
We assessed the interactions between aromatic and ornamentals plants, native and exotic, and local pollinators in the botanic garden. The list of plant species visited by *X. violacea* was analysed a) according to plant family; b) according to the geographic location where plants originated; and c) according to the flower characteristics of each species. For the latter grouping, we also d) analysed the association with legitimate or illegitimate visits. Plant geographic origin can be expected to influence flower choices due to familiarity. Different floral morphologies imply differences in availability and accessibility of floral resources (pollen and nectar) and, therefore, a different attraction potential towards *X. violacea* and other pollinators can be expected. We adopted the Pellissier et al. (2010) classification of flower characteristics: wind, disk, funnel, bilabiate, tube, head, brush. We paid special attention to differences in the foraging strategy (legitimate or illegitimate) adopted by *X. violacea*.

Results and discussion

X. violacea was recorded foraging 38 of the 400+ species present in the botanic garden. Even considering that some species and/or plant families are unsuitable to bee visits (e. g., Poaceae), we recorded bee visits to plants belonging to 13 different families. The majority of plant species belonged to the family Lamiaceae (15 species), followed by 9 species of the

Asteraceae family. The average number of bee visits, however, indicates that plants of the family Lamiaceae are preferred by *X. violacea* (Figure 1 a). Bees visited most frequently continental European and Mediterranean plants, but were also recorded on exotic species (Figure 1 b). Considering the floral morphology, we never observed visits of *X. violacea* to flowers with wind or tube characteristics. Instead, the bilabiate flower type was the most frequently visited flower type during all three years (Figure 1 c). Regarding the strategy adopted for nectar collection, the two strategies of legitimate and illegitimate visits were only observed on bilabiate flowers (Figure 1 d). Therefore, we can confirm that this behaviour is directly related to flower morphology and concealed nectar.

a)



b)

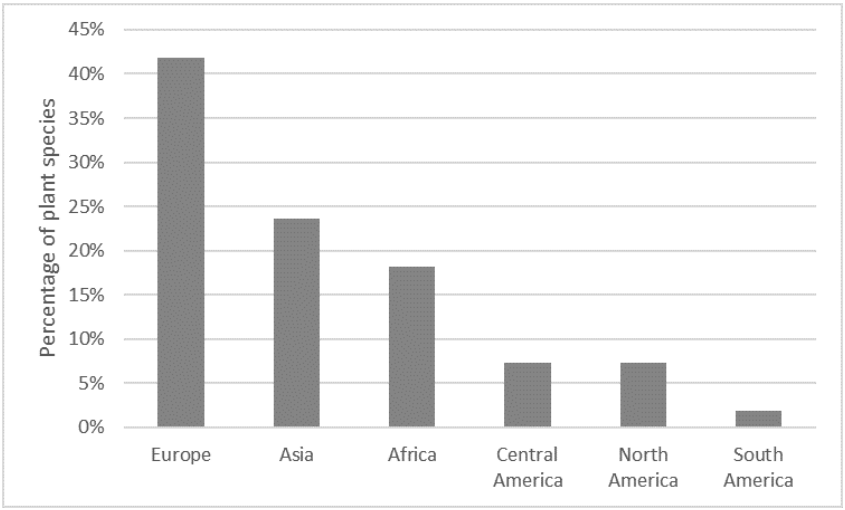
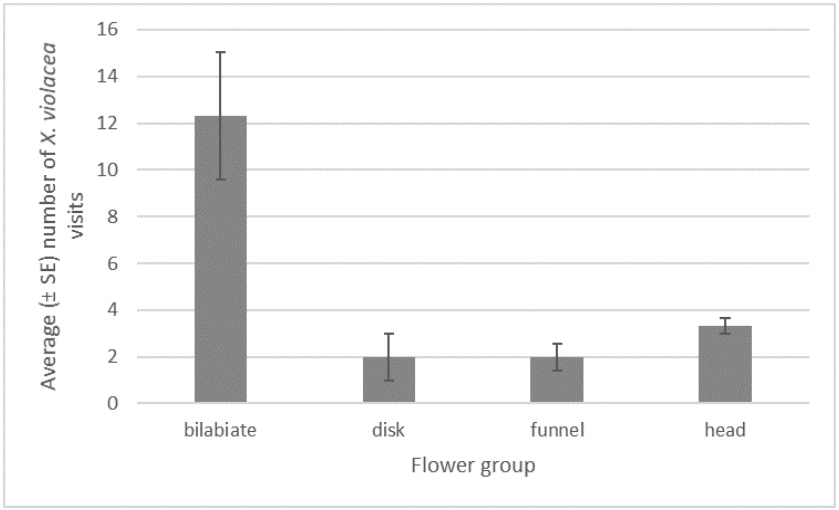


Figure 1. *X. violacea* attraction to aromatic and ornamentals species in a botanic garden. a) preference expressed in terms of plant family; b) geographic origin of visited species;

c)



d)

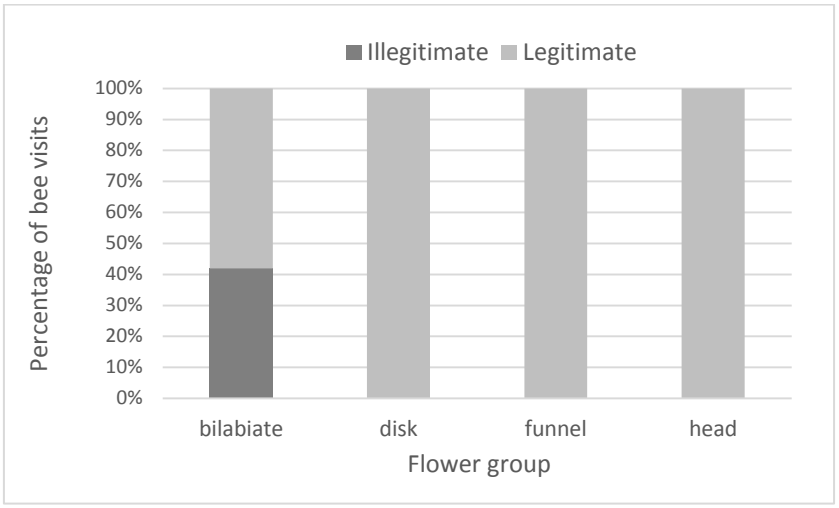


Figure 1 (continued). *X. violacea* attraction to aromatic and ornamentals species in a botanic garden. c) preferences of flower morphologies; d) distribution of legitimate and illegitimate visits.

When considering the overall bee species community, the majority of plants visited by *X. violacea* also attracted other bee visitors (Figure 2), with few exceptions (e. g. *Aconitum degenii*, *Solanum erianthum* and *Tanacetum corymbosum*). Some plant species (e. g., *Baccaroides anthelmintica*, *Cistus x incanus* and *Salvia verticillata*) were most frequently visited by bee species other than *X. violacea*.

The Ghirardi botanic garden showed a wide variety of aromatic and ornamental species able to attract local pollinators. However, among all the flowering species available, *X. violacea* limited its visits to a restricted number of plants. This generalist bee showed a preference for the family Lamiaceae, for species of continental Europe and Mediterranean origin (probably in accordance with its own geographic range), and for flowers with bilabiate characteristics. On the latter, *X. violacea* applied both legitimate and illegitimate visits. Other bee species were attracted to the same plants visited by *X. violacea*, but with different visitation frequencies. These differences, as well as possible competition for resources and pollination success, will be further studied in the future.

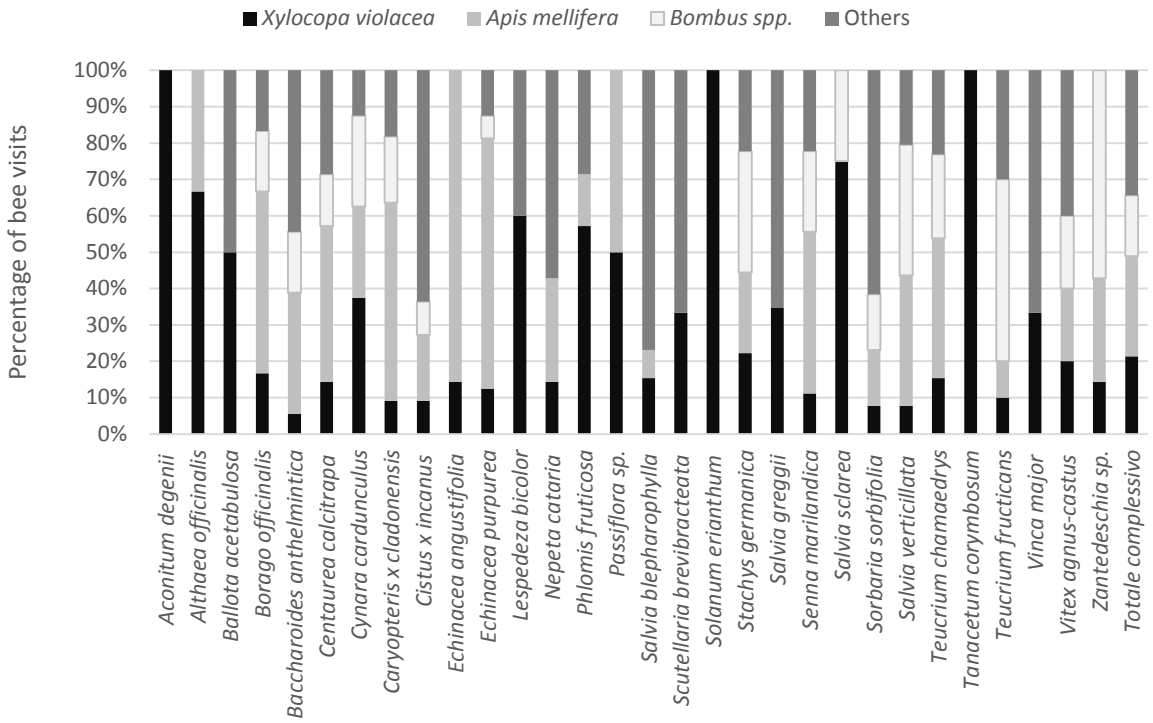


Figure 2. Visitation frequency of *X. violacea* and other bee species.

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