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Research Article

Pollinator Diversity and Abundance in a Pea Crop (*Pisum Sativa* L.) from Valladolid (Spain)

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Abstract

The present work assesses the diversity of pollinators in a pea (*Pisum sativum* L) crop from La Overuela (Valladolid, Spain). It is based on samplings carried out in 2008 that combined visual observations and the use of sweeping nets. The field work identified a total of 317 individuals, belonging to 25 genera and 42 species. The most abundant species discovered are Eucera codinai Dusmet and Alonso, 1926 with 46.68% and *Xylocopa violacea* (L. 1758) with 19.87% of abundance. Moreover, the phenological analysis clearly confirms there is a relationship between plant growth stages and the presence of pollinators in a crop commonly considered to be self-pollinating. This demonstrates the important role that pollinators play in pea cross-pollination.

Keywords: Pollinators; Natural enemies; Bees; Wild bees; Pea; *Pisum sativum*; Agriculture; Spain

Introduction

Pea - *Pisum sativum* L. (*Fabacea*)- is grown in most parts of the world. After soybean and beans, it is the third most significant legume grain [1]. In Spain, over 14,000 hectares of peas are cultivated, and its total production is almost 104,000 tons [2]. Pea plants are very resistant in case of drought and are quite undemanding in terms of soil quality [3]. As pea fixes nitrogen, it is considered very beneficial for land treatment and a good forerunner to the next crop. Pea is also used to feed livestock, to make hay and as a manure to fertilize soil [4,5]. Peas stand out for their high protein content (20–27% on average), as well as their high levels of manganese, vitamin C (antioxidant), vitamin K (important for bone health), vitamin B1 or thiamin (essential for growth), vitamin B9 or folic acid (formation of structural proteins and hemoglobin) and fiber (promotes intestinal transit). The pea flower is a classical papilionaceous formed by the union of five petals [6]. Pea flowers produce nectar that attracts many insects, mainly bee species [7,8]. Peas self-pollinate before the flower opens [9,10]. This form of reproduction also reduces ecological risks that could result from potential trans genetic migration via pollen to related wild species or other cultivars, if genetically engineered peas were to be approved for farming in the future [11,12].

However, Govorov [13] observed a cross-pollination rate of about 25% in peas. More recently, several studies have shown that the percentage may reach up to 28.57% under certain conditions [14]. Despite such research, knowledge about pea pollinators is very low; there are only few studies so far [5,15,16]. The present work examines the diversity and abundance of pollinator entomofauna in the pea crop. It was undertaken in the field station of the Agrarian Technological Institute of Castilla y León (Valladolid; Spain).

Material and Methods

Area of study

The research was carried out at the Finca Zamadueñas of the ITACyL (Agrarian Technological Institute of Castilla y León), in La Overuela (Valladolid, Spain; 41°42’09.1”N

04°42’23.0”W). The farm has a slightly continental Mediterranean climate with hot, dry, and short summers. Winters are very cold and partially cloudy. Annual rainfall is approximately 490mm. [17]. The crop covered in our study is pea (*Pisum sativum* L. 1753), which was planted in a standard-conventional design. The field size was six hectares. During the study, the agricultural practices such as fertilization and phytosanitary treatments remained unchanged (Figure 1).

Figure 1: Pea crop field view and location.

Experimental design and data analysis

Insect sampling was carried out during the flowering period of the pea crop. Given the location, this was from 6th May to 27th June 2008. During this period, to characterize the main pollinators, the crop was visited every four days, which resulted in a total of 14 field visits. Insect abundance was assessed by combining visual observations and the use of sweeping nets (observed and captured specimen numbers were merged to perform the corresponding analyses). The observations were done by moving in a zigzag along fixed transects of 50x2m during 15 minutes per line and one hour per day. Time intervals between the visits differed, they took place both on sunny and cloudy days. The collected specimens are preserved in cyanide to keep them intact and to avoid discoloration. All specimens were identified to species level using appropriate entomological literature [18-23] and have been deposited at the Andrena Entomological Collection (Valladolid, Spain; AECV). Meteorological data was collected by the meteorological station located in La Overuela (Valladolid) [17].

Results and Discussion

Diversity of insects

During the sampling period, 317 individuals belonging to three orders (Coleoptera, Diptera and Hymenoptera), 25 genera and 42 species were collected (Table 1). The most abundant genus was Eucera Scopoli, 1770 with 158 individuals (49.84%) followed by Xylocopa Latreille, 1802 with 71 individuals (22.39%). Similar results in pigeon pea (*Cajanus cajan* (L.) Millspaugh) were observed in previous studies. Otieno et al. [16] collected 1008 visitors from 31 bee genera in 49 days, with Megachile Latreille, 1802 being the most abundant genus (28.57 %). Li et al. [15] observed insect pollinators in two different locations and found 46 and 25 species in only two days.

Table 1: List and abundance of the species collected in the field of peas by sampling day. COL: Coleoptera; DIP: Diptera; HYM: Hymenoptera. Cells in green specify the number of individuals detected; cells in white indicate their absence.

Order	Species	May-2008							June-2008							Total
		6	10	14	18	22	26	30	3	7	11	15	19	23	27	
HYM	*Adalia bipunctata* (L., 1758)													2	4	6
HYM	*Amegilla quadrifasciata* (Villers, 1789)													1	1	2
HYM	*Andrena albopunctata* (Rossi, 1792)			1												1
HYM	*Andrena carbonaria* L., 1767			1												1
HYM	*Andrena flavipes Panzer*, 1799						1									1
HYM	*Andrena lepida Schrank*, 1861		1													1
HYM	*Andrena ovatula* (Kirby, 1802)			1												1
HYM	*Andrena variabilis* Smith, 1853					1										1

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HYM	*Andrena wilkella* (Kirby, 1802)			1												1
HYM	*Anthophora atroalba Lepeletier*, 1841			1	1											2
HYM	*Apis mellifera* L., 1758			1	1	1	1	1	1		1	1	1	1	1	11
COL	*Axinotarsus pulicarius* (Fabricius, 1775)													1		1
HYM	*Bibio hortulanus* L., 1758		2	4												6
HYM	*Bombus lucorum* (L., 1761)				1	1	1	1	1	1	1					7
HYM	*Bombus ruderatus* Fabricius, 1775			1	1	2	3	2	1		2		2	1		15
HYM	Ceratina chalcites Latreille, 1809					1										1
HYM	*Colletes cunicularius* (L., 1761					1										1
DIP	*Episyrphus balteatus* (De Geer, 1776)						5									5
DIP	*Eristalis tenax* (L., 1758)			2												2
HYM	*Eucera caspica Morawitz*, 1873		1													1
HYM	*Eucera codinai Dusmet y Alonso*, 1926		12	18	22	14	11	9	20		11	10	14	7		148
HYM	*Eucera elongatula Vachal*, 1907		1		1		1									3
HYM	*Eucera nigrilabris Lepeletier*, 1841	1	1		2						1					5
HYM	*Eucera rufa* (Lepeletier, 1841)	1														1
COL	*Heliotaurus ruficollis* Fabricius, 1781					1										1
HYM	*Lasioglossum aegyptiellum* (Strand, 1909)				1											1
COL	*Malachius bipustulatus* (L., 1758)										2					2
HYM	*Nomada agrestis Fabricius*, 1787				1			1								2
HYM	*Ophion sp.*				2			1		1						4
HYM	*Osmia caerulescens* L., 1758													1		1
HYM	*Osmia cornuta* (Latreille, 1805)						2									2
HYM	*Osmia niveata* (Fabricius, 1804)													1		1
HYM	*Osmia tricornis Latreille*, 1811						1									1
COL	*Oxythyrea funesta* (Poda, 1761)					1										1
DIP	*Spharophoria scripta* (L., 1758)													1		1
HYM	*Sphecodes albilabris* (Fabricius, 1773)	1														1
COL	*Tropinota squalida* (Scopoli, 1763)				2											2
COL	*Valgus hemipterus* L., 1758					1	1									2
HYM	*Xylocopa cantabrita* Lepeletier, 1841						1									1
HYM	*Xylocopa iris uclesiensis Pérez*, 1901						1									1
HYM	*Xylocopa valga Gerstaecker*, 1872			1	2	1	2									6
HYM	*Xylocopa violacea* (L., 1758)	7	9	10	6	6	9	6			2	2	4	1	1	63

Pea crop pollinators

The specific analysis showed that Eucera codinai Dusmet and Alonso, 1926 (Figure 2A) with 148 individuals (46.68%) and *Xylocopa violacea* (L. 1758) (Figure 2B) with 63 (19.87%) were the most abundant species, with 66.55% of the total abundance, followed by *Bombus ruderatus* (Fabricius, 1775) (Figure 2C) with 15 individuals (4.73%) and *Apis mellifera* L. 1758 (Figure 2D) with 11 (3.47%). These results, in combination with the conclusions drawn by Otieno et al. [16], show the strongest relationship between polli-

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nation and the carpenter bee (*Xylocopa spp*.), social bee and solitary bee guilds, which are among the most abundant bees visiting pea flowers in this system. However, they differ from those obtained by Naeem et al. [5] in Peshawar (Pakistan), where the most abundant pollinator species identified was the marmalade hoverfly (*Episyrphus balteatus* (De Geer, 1776)) with 35.22%, while in our case study we only found five individuals (1.57%) of this species. The presence of these species is closely linked to their morphology and the morphology of the pea flower. As a matter of fact, the size of the pea flower, its keel that is difficult to open, and its heavy pollen are indispensable details to consider when trying to understand the pollinators selection [8,24-26]. Indeed, insects must be very robust, so they can open the keel. In addition, they must have a long tongue to reach nectar and perform a vibration with their body called buzz pollination by which they shake the flowers and achieve efficient pollination [8,27,28]. Eventually, their body must be fit for transporting considerable loads of pollen while flying from one flower to the next [8]. Eucera codinai and *Xylocopa violacea* perfectly fit these criteria. Eucera's body is longer than 1.5cm, it has a wingspan of more than 2.2cm and a long tongue. The body of *Xylocopa* is 2.5-3cm long, its wingspan measures 4-5cm and it also has a long tongue [8,29-31]. To the contrary, the individuals of Apis mellifera are not suitable to this type of pollination service given their lack of sufficient weight and strength [32]. Ortiz-Sánchez & Aguirre-Segura [33] determined that the dry weight of *Xylocopa violacea* is 268.3mg, compared to 20.2mg only for A. mellifera. These results were reinforced by Campbell et al. [34] who analyzed the number of pollen grains in different species and observed that species of the genus *Xylocopa* generally transported around 856.000 grains while A. mellifera was able to only carry approximately 2.800 pollen grains.

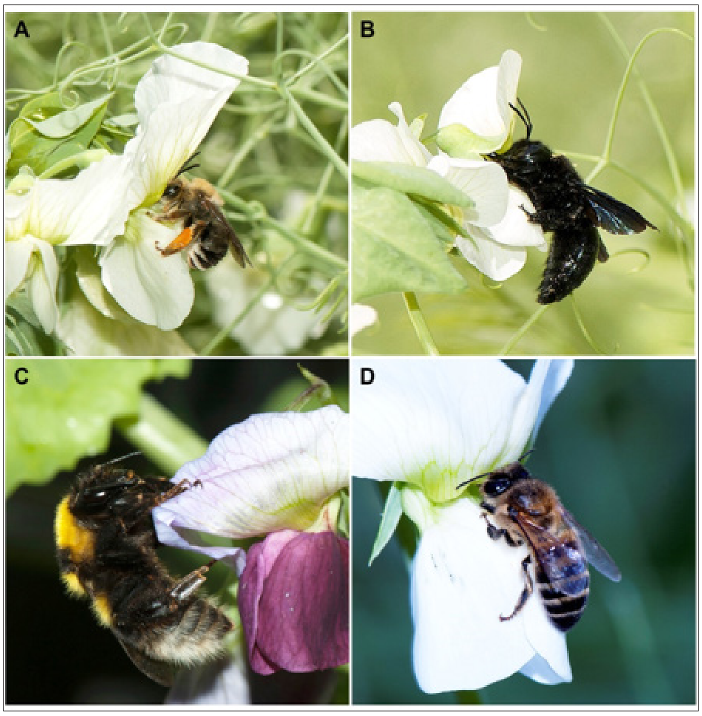

Figure 2: Most abundant bees. A. Eucera codinai Dusmet and Alonso, 1926 B. *Xylocopa violacea* (L. 1758) C. *Bombus ruderatus* (Fabricius, 1775) D. *Apis mellifera* L. 1758.

Flower-pollinator relationship

Seasonal patterns related to flower blossoming and insect abundance could be discerned. The full dataset shows that pollinators were visiting the crop throughout its entire flowering period. Species such as *E.* codinai and *Xylocopa violacea* were found on 11 and 12 days respectively, while *Bombus ruderatus* was observed on nine days (Table 1). The phenological analysis (Figure 3) clearly shows the relationship between plant growth stages and the presence and abundance of insects. As a matter of fact, pea flowers begun to open on 6th May. During the first two weeks, there was an evident increase in individuals present in the crop. On our field visits, we observed an average of 39 individuals for almost three weeks (until 26th May). After that date, the number of individuals decreased to a stable average of 18 individuals until the end of the flowering period. This decrease is clearly linked to the progressing pollination. Indeed, after one month, most of the flowers had already been pollinated. Rainy weather was the cause for the low level of individuals (2) collected on 7th June [17]. Correlating insect abundance and temperature levels shows that abundance is highest when temperatures are between 18-26 °C. These results coincide with previous research that identified temperatures from 15 to 25 °C and a relative humidity of 50-75% as ideal for insect flight and good pollination [8,35].

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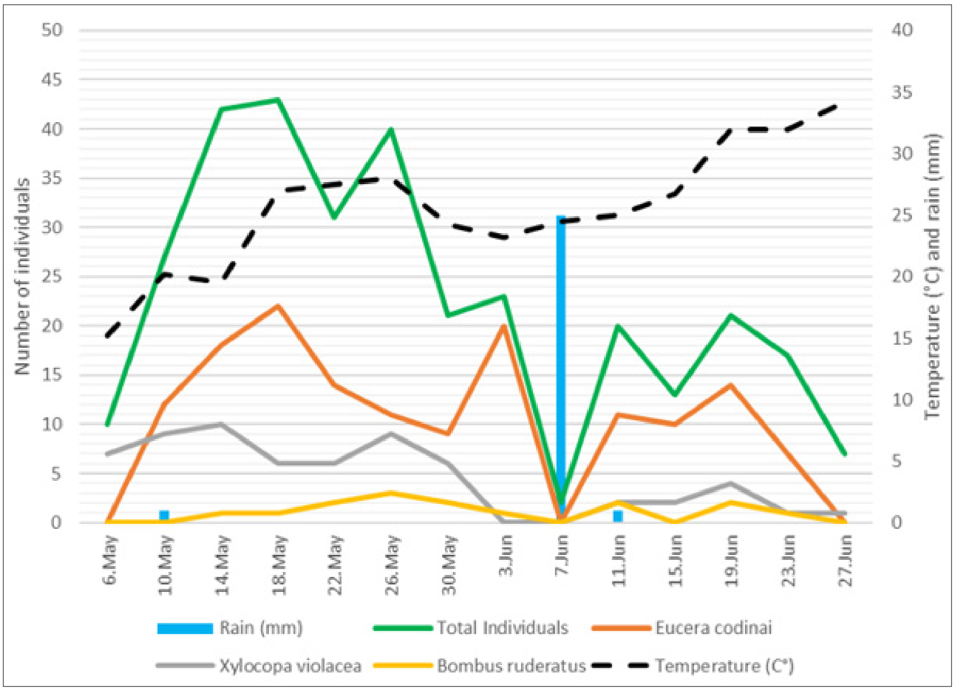

Figure 3: Relationship between climatic conditions (temperature) and the phenology and number of pollinators in pea crops.

Conclusion

This research proves that there is a great diversity and abundance of pollinating insects present in pea fields. It demonstrates the important role they play in pea cross-pollination. It also prepares the ground for future studies to examine and assess the overall impact of cross pollination and how it affects the genetic characteristics of *Pisum sativum* L. (Fabacea).

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