Insect pollination of sulla (*Hedysarum coronarium* L.) and its effect on seed production in a Mediterranean environment

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Summary - During the flowering period of 1998, insect pollinators of two varieties of *Hedysarum coronarium* L. (Grimaldi and Sparacia) were monitored in an area of Northern Sardinia (Italy). The Apidae *Apis mellifera* L. and the Anthophoridae *Eucera numida* Lep. were the main pollinators. Among the seed yield components, the number of loments per raceme and seeds per loments were 98% and 42% lower, respectively, in the absence of pollinators in Grimaldi. The percentage of flowers setting seed was about 50% in both varieties, even though the mean number of pollinators per flower was 1.4 fold higher in Grimaldi than in Sparacia.

Key-words: pollination, *Apis mellifera*, *Eucera numida*, *Hedysarum coronarium*, seed yield

Résumé - *Dans une localité du nord de la Sardegne (Italie) les insects pollinisateurs de deux variété de* Hedysarum coronarium *L. (Grimaldi and Sparacia) ont été observés pendant la floraison du 1998. L'Apidae* Apis mellifera *L. et l'Anthophoridae* Eucera numida *Lep. se sont révélés les plus abondants. En l'absence de pollinisateurs, le nombre moyen de gousses par inflorescence et le nombre moyen de graines par gousse ont été réduits respectivement de 98% et 42%. Le pourcentage des fleurs fécondées était de 50% dans les deux variétés même si le nombre moyen de pollinisateurs par fleur était 1,4 fois plus haut en Grimaldi que en Sparacia.*

Mots-clés: *pollinisation,* Apis mellifera, Eucera numida, Hedysarum coronarium, *production de graine*

Introduction

Sulla (*Hedysarum coronarium* L.) is a legume well adapted to semi-arid Mediterranean environments and represents an effective example of a multiple-uses species (Sulas *et al.*, 1997). It is considered an excellent forage species for its peculiar chemical composition and yield. In addition, sulla can also be exploited for alternative uses such as environmental protection, landscape enhancement and high quality honey production, being a crop with flowers plenty of nectar and pollen. Considerable amounts of unifloral honeys are produced in Southern and Central Italy (Ferrazzi, 1987). As in other forage legumes, cross pollination and seed production of sulla is assured by insects. Among these, *Apis mellifera* L. is the main pollinator in Central Italy with more than 90% of total flower visits (Pinzauti and Magnani, 1981, Ricciardelli D'Albore and Quaranta, 1994). In Sardinia (Italy) and especially in Tunisia, an important role is played by several wild bees and, in particular, by the Hymenoptera Anthophoridae *Eucera numida* Lep. which seems to be better adapted to the floral morphology of sulla than honey bee (Satta *et al.*, 1999; Sonet and Jacob Remacle, 1987).

The techniques adopted in intensive agriculture (e.g. continuous cropping, heavy use of chemical fertilisers, herbicides and insecticides) may dramatically reduce the presence of wild pollinators. In order to verify if such important role has been influenced by agricultural practices, it is therefore important to investigate their presence in agricultural crops.

The aim of this research was to investigate the activity of insect pollinators and estimate their effects on sulla seed production in a Mediterranean agroecosystem.

Materials and methods

The study was conducted during 1998 at the Experimental Station of the College of Agriculture of the University of Sassari, located in Northern Sardinia (Italy). At flowering (April-May) insect pollinators were monitored over an area of about 2,000 m^2 in two Italian varieties of sulla, Grimaldi and Sparacia. Pollinators were captured for their identification and their activity was estimated by 15-min counts of flower visits in 1-m^2 quadrat (3 quadrats per variety). Observations were made four time daily: 0900 - 1000, 1200 - 1300, 1500 - 1600, and 1800 - 1900 solar time. Five groups of pollinators were considered: 1) honey bees, 2) bumble bees, 3) solitary bees, 4) syrphids, and 5) other insects. Floral density of each quadrat was also monitored by counting the total number of flowers and the number of open flowers in a randomly selected subsample. Three exclosure cages of 1 x 1 x 2 m (length x width x height) were placed at the floral-bud stage to avoid pollination in the Grimaldi variety. Seed yield and its components (stems m^{-2}, racemes per stem, loments per raceme, seeds per loment and 1,000-seed weight) were measured randomly collecting 6 subsamples of 10 stems per variety both under cages and in the open field.

Results and discussion

Frequencies of pollinator visits in the two varieties of sulla are shown in table 1. *A. mellifera* was the most important pollinator but also the solitary bees were highly represented above all in Grimaldi (31% of visits). Among the solitary bees, the Hymenoptera Anthophoridae *E. numida* female was the most frequent species (64.2 and 58.5% of the total visits of solitary bees in Grimaldi and Sparacia, respectively). The presence of the remaining groups of pollinators, bumble bees (*Bombus terrestris sassaricus* Tour., *Bombus ruderatus sardiniensis* Tour.), syrphids and other insects (Lepidoptera and Coleoptera) was limited.

Flowering period was longer in Grimaldi (31 March – 23 May) than in Sparacia (3 April – 12 May), where the highest density of open flowers was recorded (figure 1). Both varieties showed a characteristic flowering pattern with two peaks. Except for the observation of 14th April, when the presence of pollinators was probably affected by the low temperature (<10 °C), a strong correlation between the number of open flowers and the number of visits was found (r^2 = 82.8%, P = 0.0003 in Grimaldi and r^2 = 69.7%, P = 0.0193 in Sparacia). Concerning the most important pollinators, *E. numida* was prevalent early in the flowering period (first week), while *A. mellifera* was dominant during the remaining period. The last presence of *A. mellifera* on the sulla flowers may be explained by the influence of the environmental conditions and/or the colony-level factors which affect the foraging patterns or efficiency in the social bees (Winston, 1987).

Table 1 – Frequencies (%) of flower visits of different pollinator groups in Spring 1998.

	Honey bee	Bumble bees	Solitary bees	Syrphids	Other insects
Grimaldi	61	1	31	2	5
Sparacia	71	3	15	1	10

Among seed yield components, the number of loments per raceme and seeds per loments were 98% and 42% lower, respectively, in the absence of pollinators in Grimaldi (table 2).

The higher seed weight recorded under cages can be explained by the lower seed number compared to that in open field. A higher number of loments per raceme, seeds per loments and a lower seed weight were observed in Sparacia than in Grimaldi. Harvested seed yield was higher in Sparacia than in Grimaldi. Both yields were reduced by the harvest efficiency, which should be improved to better exploit the sulla seed yield potential (Martiniello, 1994). Nevertheless, seed losses at harvest can be useful to increase the soil seed bank and to allow a subsequent plant regeneration from seed (Sulas *et al.*, 1999).

Based on our results, solitary bees play an important role in the pollination of sulla flowers in Mediterranean basin areas, as already shown by some observations carried out in Tunisia (Sonet and Jacob-Remacle, 1987). Nevertheless, *A. mellifera* confirmed to be the main sulla pollinator (Pinzauti and Magnani, 1981, Ricciardelli D'Albore and Quaranta, 1994). In our environmental conditions, the number of insects visiting sulla during the flowering period is probably sufficient to assure the maximum potential percentage of flowers setting seeds, which was about 50% (table 2), similarly to another experiment (Negri, 1987). In fact, by comparing the number of insects per flower in both varieties of sulla, we can conclude that a 1.4 fold higher insect number for Grimaldi than Sparacia did not produce a significant change in the percentage of seed setting.

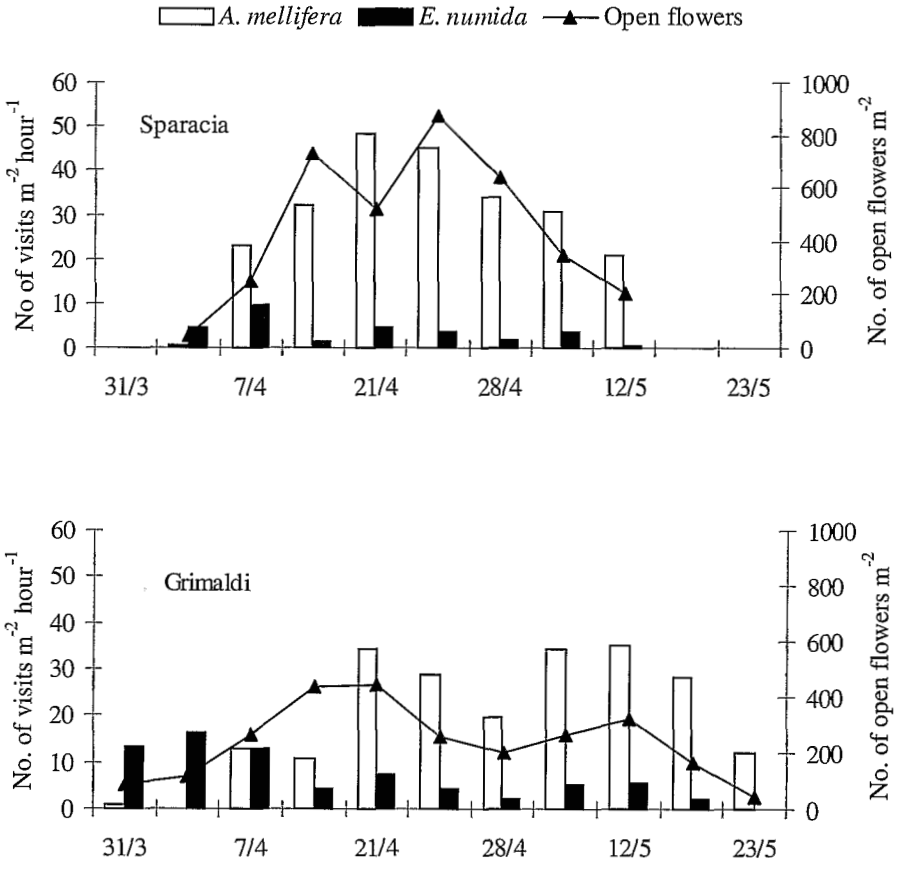

Figure 1 – Frequence of pollinators visits during flowering of two varieties of sulla.

Table 2 - Seed yield and its components and fertility index of sulla (Means ± st. deviation).

	Sparacia free pollination	Grimaldi free pollination	Grimaldi Cages
Racemes per stem (no.)	10.9 ± 1.5	11.7 ± 2.0	14.0 ± 3.4
Loments per raceme (no.)	17.3 ± 2.3	11.3 ± 2.0	0.2 ± 0.1
Seeds per loment (no.)	2.9 ± 0.4	2.6 ± 0.2	1.5 ± 0.7
1,000 seed weight (g)	4.5 ± 0.3	5.1 ± 0.2	6.9 ± 0.3
Loments/flowers (m^{-2})	47.3 ± 17.7	53.1 ± 14.2	1.0 ± 0.2
Naked seed yield* (kg ha^{-1})	210	140	0

* Harvested with a combined harvester; naked seed/loment ratio was 0.39 for both varieties.

Conclusions

The main pollinators of sulla in Northern Sardinia (Italy) were the Apidae *A. mellifera* and the Anthoporidae *E. numida*. These species seemed to be able to assure the maximum percentage of flowers setting seed (ca. 50%) in such conditions.

We observed that the highest naked seed yield was obtained for Sparacia, which showed a shorter flowering period with a higher density of open flowers compared to Grimaldi.

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