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Pollinators of some wild and cultivated forage Leguminosae in Central Italy

SUMMARY

A research on the pollinators of 62 wild and cultivated Leguminosae has been carried out in Central Italy. The most important helpful insects for cross-pollination of the considered species and their representativity have been marked. Further studies on this topic in other areas of Italy are suggested.

Key words: cross-pollination, Leguminosae

INTRODUCTION

Many studies on the pollinators and the pollination requirements of the flowers of different species of the family Leguminosae have been carried out.

Leguminosae are predominantly self-incompatible; some other few self-compatible species also need insect pollinators for pollen transfer (KIRSCHNER, 1954).

Brewbaker (1957) defines self-incompatibility as "the inability of a plant to produce male and female gametes able to yield seed, when self-pollination takes place".

Generally self-incompatibility is gametophytic homomorphic or sporophytic homomorphic and heteromorphic; in the Leguminosae it is homomorphic (LEWIS, 1949; de NETTANCOURT, 1977). Practically, there are some barriers (cytoplasmatic, genetic, etc.), which prevent the pollen grain from finishing its stigma-style-ovary pollen tube growth for ovule fertilization (DENWAND, 1963). When a plant has a S1 S2 genotype (alleles pair in the "locus", conventionally called S = Self-incompatility), the same could not be fertilized by an agent with an equal allele pair. When the pollen grain has the S1 S2 pair and meets a similar pair during its tube growth, it is stopped by the stigmatic barrier (PESSON and LOUVEAUX, 1984) and the contrary, if it meets an S3 S4 pair or others, but not S1 S2 (ARASU, 1968; TOWNSEND and TAYLOR, 1985). Moreover, during pollen ripening, some proteins responsible for self-incompatilibity are synthesized (HESLOP-HARRISON, 1975; PESSON and LOUVEAUX, 1984). There are also other obstacles (mechanical, morphological, proterandryc and protogynic phenomena, etc.) which nature generally uses to avoid self-compatibility, and secure hybrid vigour through increased genetic variability, with greater poten-

tial for adaptation to varied environmental situations (EAST, 1940; FAEGRI and VAN DER PIJL, 1979). Sometimes the species can adapt, proceeding from an entomophilous self-incompatibility to a self-compatibility (COUDERC and GORENFLOT, 1978); however all self-compatible species (only a few Leguminosae are self-compatible) take advantage of cross-fertilization, which improves the genetic patrimony (TODD, 1957; ADEY, 1984; CRANE and WALKER, 1984).

The cultivated Leguminosae have been studied very much, but the wild ones deserve greater research input. The problem is also to know how a species keeps in its floristic association, and lastly which specific pollinators are to be introduced and protected in presence of exstinguishable botanical species.

METHODS

Thirty six observations stations ranging from 800 m a.s.l. to 2500 m were established in Central Italy, mainly near the Sibillini mountains. The studies were carried out over four years (1987-1991). The pollinators of some previously described Leguminosae were once again noted (RICCIARDELLI D'ALBORE, 1980, 1983, 1984, 1985, 1986, 1988; RICCIARDELLI D'ALBORE *et al.*, 1979, 1989, 1990). Every year, during flowering of the Leguminosae (62), the pollinators were counted daily and classified (no less than 30/year), on 20 m^2 areas, usually from 10.00 to 15.00 h. The representativity was rectified with an approximation of 10% (table I). Many species flowered in various bands of the same zone and in various times of the season, hence making the work easier.

RESULTS AND DISCUSSION

Chamaecytisus hirsutus L., very common in calcareous and rocky zones, is primarily used by goats. The flowers have a long corolla, and are mainly visited by Lepidoptera or Hymenoptera with a long ligula (*Anthophora*, *Bombus*, *Eucera*, *Xylocopa*). Honeybees also visit this species, but only to collect pollen (systematics of Zangheri P., 1976) (table I).

Genista sagittalis L., very plentiful near the great plain of Castelluccio of Norcia, is visited by goats and sheep. Its flowers have a relatively short corolla and the most important pollinators are Lepidoptera, a few bumblebees and honeybees (table I).

Lupinus albus L., cultivated for seed production or used as green manure it does not produce nectar, but pollen is collected from it by Hymenoptera with long ligula, and also honeybees. Its corolla is relatively short and the

literature considers it partly self-compatible, although cross-pollination (40%) is helpful (WALLACE *et al.*, 1954; BOHART, 1960; RICCIARDELLI D'ALBORE, 1984a; WILLIAMS *et al.*, 1990) (table I).

Galega officinalis L. The most important pollinators of this non nectariferous short corolla species are pollen collecting honeybees (BATTAGLINI and RICCIARDELLI D'ALBORE, 1970a, b) less representative Diptera, *Lasioglossum* spp. and bumblebees (RICCIARDELLI D'ALBORE, 1985b) (table I).

Astragalus spp. have long corollae and are considered self-incompatible (seldom compatible) (TOWNSEND, 1978) (table I)

Astragalus echinatus Mür. The most frequent pollinators of this long corolla species are *Eucera* spp. and *Anthophora acervorum* L.; bumblebees are of lesser importance (table I).

Astragalus sempervirens L., a typical species of calcareous zones, up to 2000 m a.s.l. has long thorns and is foraged only by goats. At 1000-1200 m, the honeybees are very frequent visitors whereas at 2000 m it is visited for both nectar and pollen by bumblebees (RICCIARDELLI D'ALBORE, 1986).

Astragalus sirinicus Ten., only present at higher altitudes (> 1800 m-Rotondo mountain). It has a long corolla and is visited by some Lepidoptera and many bumblebee species. *A. depressus* L. is visited by the same pollinators (table I).

Astragalus glycyphyllos L., chiefly studied in the botanical gardens of Perugia, has a relatively long corolla. It is mainly pollinated by honeybees (MENGHINI and RICCIARDELLI D'ALBORE, 1979). Occasional visitors are Lepidoptera, *Anthophora* spp. and bumblebees (RICCIARDELLI D'ALBORE, 1984a) (table I).

Astragalus glycyphyllos L. f. Setinger, is found near Norcia (800-900 m high). It has a very long corolla and bumblebees are regular pollinators (table I).

Oxytropis campestris DC. From the few observations made bumblebees seem to be the most important pollinators of this species.

Vicia spp. Very important pollinators for the *Vicia* genus are bumblebees and honeybees (ALEV *et al.*, 1950; WEAVER, 1956); *Melitta*, *Megachile*, *Osmia* and Lepidoptera (long corolla) are less assiduous. Some species (*V. sativa* L.) are considered to be self-compatible, others are self-incompatible; anyhow cross-pollination is helpful (ANDERSON, 1958; BOHART, 1960; RISIUS, 1968; FREE, 1970; MC. GREGOR, 1976; TOWNSEND, 1978). *Vicia cracca* L. is a very important nectariferous and polliniferous source for bumblebees particularly in the spring (RICCIARDELLI D'ALBORE, 1986).

POLLINATORS (%)

SPECIES	ALTITUDE m	LEP.	MUS. CAL.	SYRPH.	BOM.	PROS.	AND.	HAL.	LAS.	MEL.	MEG.	CHAL.	ANT.	OSM.	EUC.	ANTH.	XYL.	BOMB. PS.	APIS
**Chamaecytisus hirsutus* Link.	500	-	-	-	-	-	-	-	-	-	-	-	-	-		10-20	10-20	-	50-60
**Chamaecytisus hirsutus* Link.	1400	< 10	-	-	-	-	-	-	-	-	-	< 10	-	-	< 10	< 10	< 10	20-30	10-20
**Genista sagittalis* L.	1400	70-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 10	< 10
#*Lupinus albus* L.	500	-	-	-	-	-	-	-	-	-	-	-	30-40	< 10	< 10	30-40	-	-	10-20
**Galega officinalis* L.	500	-	< 10	< 10	-	-	-	-	< 10	-	-	-	-	-	-	-	-	10-20	40-50
¥*Astragalus echinatus* Mür.	1300-1600	20-30	-	-	-	-	-	-	-	-	-	-	-	-	40-50	< 10	-	20-30	-
**Astragalus sempervirens* Lam.	1200	< 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10-20	60-70
**Astragalus sempervirens* Lam.	2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	> 90	
¥*Astragalus sirinicus* Ten.	1800-2100	10-20	-	-	-	-	-	-	-	-	-	-	-	-	< 10	< 10	-	50-60	< 10
o#*Astragalus depressus* L.	1400	10-20	-	-	-	-	-	-	-	-	-	-	-	-	< 10	< 10	-	50-60	< 10
o#*Astragalus glycyphyllos* L.	500	< 10	-	-	-	-	-	-	-	-	-	-	-	-	-	< 10	-	< 10	60-70
o#*Astragalus glycyphyllos* L. f. *Setinger*	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	< 10	< 10	< 10	60-70	-
¥*Vicia atropurpurea* DC.	1400	10-20	-	-	< 10	-	-	-	-	< 10	-	-	-	-	-	-	-	20-30	20-30
o#*Vicia lutea* L.	300-800	< 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	> 90	-
¥*Vicia sylvatica* Schreb.	1400	10-20	-	-	< 10	-	-	-	-	-	-	-	-	-	-	-	-	30-40	20-30
¥*Vicia onobrychioides* L.	800-1500	10-20	-	-	< 10	-	-	-	-	-	-	-	-	< 10	< 10	-	-	40-50	-
¥*Vicia cracca* L.	500-1400	< 10	-	-	-	-	-	-	-	-	< 10	-	-	< 10	-	-	-	20-30	40-50
¥*Vicia pseudocracca* L.	1400	10-20	-	-	< 10	-	-	-	-	-	-	-	-	-	-	-	-	30-40	20-30
¥*Vicia tenuifolia* L.	1400	10-20	-	-	< 10	-	-	-	-	< 10	-	-	-	-	-	-	-	30-40	10-20
#*Vicia sativa* L.	1400	10-20	-	-	< 10	-	-	-	-	-	-	-	-	-	-	-	-	40-50	10-20
**Lathyrus vernus* Bernh.	400	< 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 10	70-80	-
¥*Lathyrus sylvestris* L.	500-1200	< 10	-	-	< 10	-	-	-	-	-	-	< 10	-	-	< 10	< 10	30-40	< 10	-
¥*Lathyrus pratensis* L.	500-1400	20-30	-	-	-	-	10-20	-	-	< 10	-	-	-	-	-	-	-	20-30	< 10
**Ononis spinosa* L.	1200	10-20	-	-	-	-	< 10	< 10	-	-	-	-	-	20-30	-	-	-	-	20-30
¥*Melilotus officinalis* Pallas	600	< 10	-	< 10	-	-	< 10	< 10	< 10	-	-	-	-	-	-	-	-	-	40-50
¥*Melilotus italica* Lam.	600	< 10	-	-	-	< 10	-	-	< 10	-	-	-	-	-	-	10-20	< 10	-	30-40
¥*Melilotus alba* Medicus	600	< 10	-	< 10	-	-	< 10	-	< 10	-	-	-	-	-	-	-	-	-	50-60
¥*Medicago rigidula* All.	500	10-20	< 10	10-20	-	< 10	< 10	< 10	< 10	-	-	-	-	-	-	-	-	-	< 10
o#*Medicago arabica* Hudson	500	10-20	< 10	10-20	-	< 10	< 10	-	10-20	-	-	-	-	< 10	-	-	-	-	-
o#*Medicago lupulina* L.	500-1400	-	< 10	-	-	< 10	-	< 10	< 10	-	-	-	-	-	-	-	-	-	50-60
¥*Medicago sativa* L.	500	< 10	-	-	-	-	30-40	-	-	< 10	< 10	-	-	-	-	-	-	< 10	10-20
¥*Medicago sativa* L.	1400	10-20	-	-	-	-	-	-	-	-	10-20	< 10	-	-	-	-	-	30-40	< 10
¥*Medicago sativa* L. subsp. *glomerata* Tutin	1000	10-20	-	-	-	-	-	-	-	-	10-20	< 10	-	-	-	-	-	< 10	30-40
¥*Medicago sativa* L. subsp. *falcata* Arc.	1000	10-20	-	-	-	-	-	-	-	-	10-20	< 10	-	-	-	-	-	< 10	30-40
¥*Medicago arborea* L.	100-600	-	-	-	-	-	< 10	-	-	-	-	-	-	< 10	-	-	< 10	< 10	80-90
¥*Trifolium badium* Schreb.	1400	10-20	-	< 10	-	< 10	< 10	10-20	< 10	-	-	-	-	-	-	-	-	< 10	30-40
¥*Trifolium nigrescens* Sibth.	1400	10-20	-	-	-	-	< 10	< 10	< 10	-	-	-	10-20	-	-	-	-	-	20-30
#*Trifolium campestre* Schreb.	1400	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-	< 10	-	-	-	-	10-20

Species	Altitude m	Lep.	Mus. Cal.	Syrph.	Bom.	Pros.	And.	Hal.	Las.	Mel.	Meg.	Chal.	Ant.	Osm.	Euc.	Anth.	Xyl.	Bomb. Ps.	Apis
¥*Trifolium alpestre* L.	1400-2000	20-30	-	-	< 10	-	< 10	-	-	-	-	-	-	-	< 10	-	< 10	10-20	-
¥*Trifolium rubens* L.	900	-	-	-	-	-	-	< 10	-	-	-	-	-	-	-	20-30	-	20-30	20-30
¥*Trifolium stellatum* L.	500	10-20	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-	-	-	-	-	-	10-20
¥*Trifolium incarnatum* L.	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 10	-	< 10	70-80
¥*Trifolium medium* L.	1200	10-20	< 10	-	< 10	-	< 10	< 10	< 10	< 10	-	-	-	-	-	-	-	< 10	< 10
¥*Trifolium pratense* L.	500	-	-	-	-	-	< 10	< 10	-	-	-	-	-	-	< 10	< 10	-	40-50	< 10
¥*Trifolium pratense* L.	1400	< 10	-	-	-	-	-	-	-	-	-	-	-	-	< 10	< 10	-	60-70	-
¥*Trifolium alpinum* L.	1800-2500	< 10	-	-	-	< 10	-	-	-	-	-	-	-	-	-	-	-	70-80	-
¥*Trifolium purpureum* Loisel	1400	< 10	-	-	< 10	-	-	20-30	-	-	-	-	-	-	-	-	-	30-40	< 10
¥*Trifolium ochroleucon* Hudson	800-1800	-	-	-	-	-	-	-	-	-	-	< 10	-	-	< 10	-	-	70-80	-
¥*Trifolium montanum* L.	1200-2000	< 10	-	-	< 10	-	-	< 10	-	-	-	-	-	-	< 10	-	-	30-40	10-20
o#*Trifolium scabrum* L.	500-1800	20-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60-70	-
¥*Trifolium bocconei* Savi	800	10-20	-	-	< 10	-	< 10	-	-	-	-	-	-	< 10	< 10	-	-	10-20	10-20
¥*Trifolium fragiferum* L.	800	< 10	-	-	-	< 10	< 10	< 10	< 10	-	-	-	-	-	-	-	-	10-20	20-30
¥*Trifolium thalii* Vill.	1700-2200	20-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60-70	-
¥*Trifolium hybridum* L.	1200	< 10	< 10	< 10	-	-	< 10	-	< 10	-	-	-	-	-	-	-	-	-	40-50
¥*Trifolium repens* L.	600-2000	< 10	-	-	-	-	< 10	-	-	-	-	-	-	-	-	-	-	< 10	60-70
**Dorycnium pentaphyllum* Scop.	1000	-	-	< 10	-	< 10	< 10	< 10	< 10	-	-	-	-	-	-	-	-	-	40-50
**Dorycnium rectum* Ser.	500	< 10	-	< 10	-	-	< 10	-	-	-	-	-	-	-	-	-	-	-	60-70
**Dorycnium hirsutum* Ser.	200	< 10	-	-	-	-	-	-	-	-	-	-	-	-	-	< 10	< 10	40-50	10-20
¥*Lotus corniculatus* L.	500-1800	< 10	-	-	-	-	< 10	-	-	10-20	-	-	20-30	-	-	-	-	-	20-30
¥*Lotus tenuifolius* Reichenb.	500-1800	< 10	-	-	-	-	< 10	-	-	10-20	-	-	20-30	-	-	-	-	-	20-30
**Securigera securidaca* Degen et Dorf.	1400	30-40	< 10	< 10	-	-	-	< 10	< 10	-	-	-	-	-	-	-	-	-	10-20
o#*Anthyllis vulneraria* L.	1200	20-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10-20	50-60
¥*Anthyllis montana* L.	1800	20-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20-30	30-40
**Coronilla coronata* L.	1200	< 10	< 10	< 10	-	< 10	< 10	10-20	< 10	-	-	-	-	< 10	-	-	-	-	< 10
**Coronilla minima* L.	1200	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-	-	-	-	-	10-20
¥*Coronilla varia* L.	1200	10-20	-	-	< 10	-	< 10	-	-	-	-	-	-	< 10	-	-	< 10	10-20	10-20
**Hippocrepis comosa* L.	1200	10-20	< 10	< 10	-	-	< 10	< 10	-	-	-	-	-	-	-	-	-	-	30-40
¥*Hedysarum coronarium* L.	200	< 10	-	-	-	< 10	< 10	-	-	-	-	-	-	-	-	-	-	< 10	50-60
¥*Onobrychis viciifolia* Scop.	800-1400	< 10	-	< 10	-	-	-	-	-	20-30	-	-	-	-	-	-	-	< 10	30-40
¥*Onobrychis montana* DC.	1500	< 10	-	-	-	-	-	-	-	20-30	-	-	-	< 10	-	-	-	< 10	30-40

Tab. I - Rapresentativity (%) of the most important pollinators of the forage Leguminosae in Central Italy

Legenda: LEP. = Lepidoptera, MUS. = Diptera Muscidae, CAL. = Diptera Callyphoridae, SYRPH. = Diptera Syrphidae, BOM. = Diptera Bombylidae, PROS. = *Prosopis*, AND. = *Andrena*, HAL. = *Halictus*, LAS. = *Lasioglossum*, MEL. = *Melitta*, MEG. = *Megachile*, CHAL. = *Chalichodoma*, XYL. = *Xylocopa*, ANT. = *Anthidium*, OSM. = *Osmia*, EUC. = *Eucera*, ANTH. = Anthophora, BOMB. & PS. = *Bombus* and *Psithyrus*, APIS.= *Apis mellifera*, * = unknown compatibility, ¥ = self-incompatible, # = self-compatible, o# = self-compatible, incompatible by some varieties, compatible adaptation to the environment.

Lathyrus spp. have relatively short corollae; the best pollinators on *L. sylvestris* L. and *L. vernus* L. are bumblebees and on *L. pratensis* L., Lepidoptera and bumblebees (table I).

Ononis spinosa L. because of its many thorns only the new spring plants can be foraged. It has a very short corolla and is infrequently visited by pollinators, with bumblebees having a low representation (table I).

Melilotus officinalis Lam. New spring plants are foraged by cattle. The flowers have short corollae and the best pollinators are honeybees (MENGHINI and RICCIARDELLI D'ALBORE, 1979; RICCIARDELLI D'ALBORE, 1983). The species is self-incompatible (BOHART, 1960; FREE 1970; MC GREGOR, 1976; TOWNSEND, 1978).

Melilotus alba Medicus and *M. italica* Lam. Honeybees are always the best pollinators (table I) (RICCIARDELLI D'ALBORE, 1983). These species are considered self-compatible, although some varieties are self-incompatible (BOHART, 1960; MC GREGOR, 1976).

Medicago spp. Only *M. sativa* L. is cultivated. Some sub-species (*M. glomerata* Tutin and *M. falcata* Arc.) are wild; other species (table I) are also wild in various floristic associations. Many pollinators (Lepidoptera, *Chalichodoma*, *Megachile*) visit; the best pollinator, at 500 m, is *Andrena flavipes* Panz. while at higher zones, the bumblebees dominate. Although the corolla is short, honeybees are not good pollinators, because they avoid tripping (RICCIARDELLI D'ALBORE, 1984b, 1986, 1989). Only *M. lupulina* L. (short corolla) is self-compatible but cross-pollination (above all honeybees) improves the seed production (MC GREGOR, 1976) (table I).

Trifolium spp. Those cultivated in Umbria are *T. incarnatum* L., *T. pratense* L., *T. hybridum* L. and *T. repens* L., and rarely *T. rubens* L.; the remaining observed species are all wild, in the mountain pastures. The visits of the Lepidoptera are the same for each species; Diptera are infrequent visitors and may be not efficacious; *Halictus rubicundus* Christ is very important for *T. purpureum* Loisel. Due to a long corolla the best pollinators are the bumblebees (PLOWRIGHT and HARTLING, 1981); sometimes the best pollinators are the honeybees (*T. incarnatum,* with a relatively short corolla) (ATWOOD, 1943; AMOS, 1951) (table I).*Trifolium* spp., barring *T. campestre* Schr. and *T. subterraneum* L. are self-incompatible (WILLIAMS, 1951; BOHART, 1960; FREE, 1970; MC GREGOR, 1976; TOWNSEND, 1978; PESSON et LOUVEAUX, 1984). Some varieties of *T. repens* are considered self-compatible, others incompatible (FREE, 1970).

Dorycnium spp. Many pollinators are present on this genus (table I), but their density is always reduced. The honeybees are the best pollinators of *D. pentaphyllum* Scop. and *D. rectum* Ser. which have short corollae, while the

bumblebees are the best pollinators of *D. hirsutum* Ser. which has a relatively long corolla (table I). The compatibility of this species is unknown.

Lotus corniculatus L., seldom cultivated, is widespread species. The important pollinators (very specific) are *Anthidium punctatum* Latr. and *A. oblongatum* Latr. The honeybee is also a very good pollinator of its flowers with their very short corolla. *Lotus* spp. are self-incompatible (FREE, 1970; RICCIARDELLI D'ALBORE, 1984b).

Lotus tenuifolius Reichenb. takes advantage from the same pollinators.

Securigera securidaca Degen et Dorf. is mostly visited by Lepidoptera; the honeybees, Diptera and Halictidae are less important (table I). Compatibility of this species is unknown (RICCIARDELLI D'ALBORE and PERSANO ODDO, 1978).

Anthyllis vulneraria L., abundant in the mountain pastures, has many varieties with variable chromatic appearances (very long corolla). Lepidoptera, bumblebees and a few honeybees are assiduous visitors and good pollinators (table I). The species has adapted itself to self-compatibility, but cross pollination occurs for some varieties (COUDERC - GORENFLOT, 1978).

Anthyllis montana L. Visitors are the same as for *A. vulneraria.* The species lives at high altitudes (over 1700 m); it has a short corolla and is considered proterandric (COUDERC, 1980).

Coronilla spp. are foraged above all by goats; *C. varia,* which is partially toxic, is seldom visited (table I). *C. varia* is self-incompatible with a short corolla (MC GREGOR, 1976; RICCIARDELLI D'ALBORE and PERSANO ODDO, 1978).

Hyppocrepis comosa L. is not widespread in the mountain pastures; honeybees are the best pollinators of its short corolla flowers (table I). The species is self-incompatible (BOHART, 1960).

Hedysarum coronarium L. Typical forage of clayey soils draws advantages from the honeybee visits. The species is self-incompatible (SACCHI, 1953). New observations in the botanical gardens of Perugia have shown a low percentage of self-compatibility (7%); its flowers have short corollae (RICCIARDELLI D'ALBORE, 1984a).

Onobrychis spp. In Umbria, the cultivated *O. viciifolia* Scop. is the most important forage in appennine zones; however it also grows in lower zones. The most important pollinators are the honeybees and, in the mountains (1400 m) *Melitta dimidiata* Mor; the bumblebees are less important. It has relatively short corolla (RICCIARDELLI D'ALBORE, 1985; 1990 *et al.*).

Table II. Main Lepidoptera Rhopalocera pollinators of the forage Leguminosae in Central Italy.

Adopaea lineola O.
A. silvestris Poda
Agapetes galathea L.
Aporia crataegi L.
Apatura ilia Schiff.
Argynnis paphia L.
Brintesia circe F.
Coenonympha pamphilus L.
Colias croceus Fourc.
C. hyale L.
Dira megera L.
Erebia euryale Esp.
E. manto Schiff.
E. mnestra Hbn.
Gonepteryx cleopatra L.
G. rhamni L.
Hipparchia semele L.
Inachis Io L.
Iphiclides podalirius L.
Lycaeides idas L.
Lycaena spp.
Lysandra argester Bergstr.
Maniola janira L.
Nymphalis polychloros L.
Papilio machaon L.
Pararge ungera L.
Parnassius apollo L.
Pieris brassicae L.
P. rapae L.
Pironia cecilia Vall.
Vanessa atalanta L.
V. cardui L.
Zygaena ephialtes L.
Z. trifolii Esp.

THE POLLINATORS

Lepidoptera (table II). Their pollinator value is due to the floral adaptation, according to whether the insect is diurnal (Psycophilia), nocturnal (Phalaenophilia) or typical of the family of Sphingidae (Sphingophilia) (Pesson and Louveaux, 1984). Diurnal and nocturnal Lepidoptera can transport pollen with their proboscis and the rest of the body, while Sphingidae, only with their mouth apparatus. They are important as additional pollinators of Leguminosae, but are not so efficacious as the Hymenoptera. They have not been identified, because their role in pollinating Leguminosae is uncertain. However many species are visitors.

Diptera Bombylidae. *Bombylius canescens* Mik, *B. minor* L., *B. major* L., *B. pumilus* Meig. are infrequent and fly quickly on all the Leguminosae, particularly on *Onobrychis viciifolia.*

Diptera Syrphidae. *Syrphus vitripennis* Meig., *S. pyrastri* L., *S. luniger* Meig., *S. torvus* Ost., *S. ribesii* Meig, *S. seleniticus* Meig., *S. balteatus* De Geer, *S. nitens* Zett. and *Volucella bombylans* L. are the most important visitors. Like in the Leguminosae with a short corolla they can be helpful for cross-pollination.

Hymenoptera Apoidea (table III) are the most effective pollinators of the Leguminosae; they can be monoleptic (*Anthidium* spp., some *Andrena*), oligoleptic (*Megachile* spp., *Melitta* spp.) or polyleptic (*Bombus* spp. and *Apis mellifera ligustica* Spin.) and represent a very rich entomofauna for pollina-

Table III. Main Apoidea pollinators of the forage Leguminosae in Central Italy.

COLLETIDAE

Colletes maidli Noskievicz
C. similis Schenk.

HALICTIDAE

Halictus fulvipes Klug
H. maculatus Smith
H. quadricinctus Fabr.
H. rubicundus Christ.
H. scabiosae Rossi
H. seladonius Fabr.
H. simplex Blüthgen
H. subauratus Rossi
Lasioglossum albipes Fabr.
L. calceatum Scop.
L. costulatum Kriech.
L. interruptum Panz.
L. malachurum K.
L. punticolle Mor.
L. sexnotatus K.

ANDRENIDAE

Andrena aeneiventris Mor.
A. bicolorata Rossi
A. bisulcata Mor.
A. cinerea Brullè
A. flavipes Panz.
A. florentina Magr.
A. hattorfiana F.
A. humilis Imh.
A. labialis K.
A. minutula K.
A. ovatula K.
A. schmiedeknechti Magr.
A. ventricosa Dours.
Panurgus banksianus K.
Nomada armata Herr. Sch.
N. brawnsiana Schm.

MELITTIDAE

Melitta leporina Panz.
M. tricincta K.
M. dimidiata Mor.

MEGACHILIDAE

Anthidium manicatum L.
A. oblongatum Latr.
A. punctatum Latr.
Anthidiellum strigatum Panz.
Stelis signata Latr.
Megachile apicalis Spin.
M. brachella Curtis
M. centruncularis L.
M. circumcincta K.
M. lagopoda L.
M. melanopyga Costa
M. pilidens Aifk.
M. versicolor Smith.
M. willoughbiella K.
Chalicodoma muraria Retz.
C. parietina nestorga Br.
Hoplitis adunca Panz.
H. rufihirta Latr.
Osmia aurolenta Panz.
O. cornuta Latr.
O. fulviventris Panz.
O. rufa L.
O. versicolor Latr.

APIDAE

Xylocopa violacea L.
Eucera clypeata Erich.
E. longicornis L.
E. similis Lep.
E. tuberculata Fabr.
Anthophora acervorum L.
A. albigena Lep.
A. crinipes Smith.
Bombus lucorum L.
B. terrestris L.
Pyrobombus pratorum L.
P. soroënsis Fabr.
P. lapidarius L.
P. monticola konradini Reinig.
P. sicheli alticola Kriechb.
Megabombus sylvarum distinctus Vogt.
M. ruderarius Müller
M. humilis appeninus Vogt.
M. pascuorum Scop.
M. mesomelas Gerst.
M. subterraneus L.
M. subterraneus latreillelus K.
M. ruderatus atrocorbiculosus Vogt.
M. ruderatus eurynotus Kriechb.
M. hortorum L.
Psithyrus campestris Panz.
P. maxillolus Klug.
P. maxillosus italicus Gr.
P. rupestris Fabr.
P. sylvestris Lep.
P. vestalis Fourer.
Apis mellifera ligustica Spin.

tion in Central Italy (Westrich, 1990). The main species are ubiquitous, but others (*Andrena*, *Megachile*, *Pyrobombus sicheli alticola* Kriechb., *P. monticola konradini* Reinig.) are adapted to certain altitudes only (RICCIARDELLI D'ALBORE, 1986). Some are very good pollen gatherers with the three typical and main collecting modalities (corbicula - Apidae; abdominal hair-brush - Megachilidae; femur-tarsus system - Andrenidae, Halictidae etc.). Many pollinators also collect nectar; some are very quick (*Osmia*, *Anthidium*, etc.), other slow (*Psithyrus*, *Andrena*, etc.). Many species only occasionally land on the Leguminosae (*Megachile lagopoda* L., *M. willoughbiella* Kirby, *Anthidium manicatum* L., many of the genus *Andrena*, *Halictus*, etc.); many others are assiduous on some species (*Halictus rubicundus* on *Trifolium purpureum*, *Melitta dimidiata* on *Onobrychis viciifolia*, *Eucera* spp. on *Astragalus echinatus*, *Melitta leporina* L. on *Medicago sativa* (sometimes also *Andrena flavipes*), *Anthidium* spp. on *Lotus corniculatus*, etc.).

The small Apoidea (*Lasioglossum*, *Prosopis*, etc.) are more capable pollinators of Leguminosae with a short corolla; Apoidea with long tongues are better for all the Leguminosae (*Eucera*, *Anthophora*, *Bombus*, etc.) (tables I-III). Finally, some species have certainly escaped observation, but they are likely rare or occasional.

CONCLUSIONS

The following conclusions can be drawn:

- Apoidea are the best and prevalent pollinators of the Leguminosae in Central Italy;
- the role of solitary bees, bumblebees and honeybees as pollinators is quite varying;
- further research is needed to fully determine which species are the most important pollinators of wild and cultivated Leguminosae in other areas of Italy;
- the compatibility status of some wild species should be more exhaustively studied on controlled experimental grounds.

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RIASSUNTO

IMPOLLINATORI DI ALCUNE LEGUMINOSAE FORAGGERE SPONTANEE E COLTIVATE NELL'ITALIA CENTRALE.

E' stata svolta nell'Italia centrale una ricerca sugli insetti impollinatori di 62 Leguminosae spontanee e coltivate. Sono stati segnalati i principali insetti artefici della fecondazione incrociata delle specie esaminate e la relativa rappresentatività. Si suggerisce un ulteriore approfondimento sul tema in altri ambienti italiani.

Parole chiave: impollinazione incrociata, Leguminosae

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