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Input to the knowledge of the melliferous plants diversity in Babors Kabylia's region (North-East of Algeria)

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Abstract

The Kabylie of Babors (NE Algeria) is considered a hotspot for Mediterranean biodiversity exhibiting a great diversity of melliferous plants. In this paper an inventory of spontaneous and cultivated plants whose flowers were frequently visited by bees (*Apis mellifera* L.) has been performed. The main objective of identifying and classifying these plants was to contribute to a better knowledge of honeybee resources and to know what types of honey can be produced in this region. This may also help palynologists to identify the pollen grains in honey and thus determine its botanical origin. The floristic inventory was initiated throughout the study area during spring 2018 to spring 2019 over a radius of two to three kilometers around the apiaries. Plants were then recorded and identified. In addition, 27 honey samples were collected directly from beekeepers and were analyzed for pollen spectra. Two hundred and eighty four melliferous species belonging to 60 families have been identified, the most representative families were Fabaceae (*Genista*, *Trifolium*, *Lotus*, *Ononis*, *Hedysarum coronarium* L., *Calicotome spinosa* (L.) Link, *Retama sphaerocarpa* (L.) Boiss, *Spartium junceum* L.) Asteraceae (*Bellis*, *Carduus*, *Aster, Cichorium intybus* L.,*Galactites tomentosa* Moench.), Lamiaceae (*Stachys, Teucrium*, *Lamium, Vitex agnus-castus* L.) and other important taxa such as *Erica*, *Eucalyptus*, *Myrtus communis* L., *Pistacia lentiscus* L. The results of the melissopalynology showed more than 88 taxa belonging to 44 families.

Keywords: *babors Kabylia, beekeeping, honey, honeybee, melliferous species, pollen analysis*

Introduction

Since antiquity, humans have been attracted to bees because of the enormous service they provide supplying bee products and ensuring the pollination of crops. Beekeeping is a primary sector, which deliver great benefits for ecosystems and has low environmental impact. Its development depends on several factors including the abundance of pollen and nectar resources in the area and around the apiary (Cuthbertson and Brown 2006).

In Algeria, apiculture is a productive activity considered as a part of the agricultural and rural routine. It is practiced in several regions but more frequently in the north of the country due to the favorable climatic conditions and the high floristic biodiversity, which supplies melliferous resources during almost the whole year (Hussein 2000). There are more than 20,000 beekeepers of whom 90% are amateurs and only 10% are professionals, own 700,000 hives, mainly modern hives (Langstroth type and Dadant type) and very few traditional hives (Ghorab et al 2021). The main honeybee species raised is *Apis mellifera intermissa* and honey production is relatively low, varying from 5 kg to up to 20 kg of honey per hive, despite the intensification of the use of modern hives (Laallam et al 2011).

The most important monofloral honey types produced are *Eucalyptus*, *Citrus*, Heather, Jujube and Sulla (Nair et al 2013; Zerrouk et al 2018; Homrani et al 2020; Ghorab et al 2021). However, considering the wide diversity of the area, some other valued monofloral honeys can be obtained. For this purpose, melissopalynological analysis of honey coupled with a good knowledge of the flora in the region represents a very efficient technique for the determination of honeybee preferences and honey classification.

Nowadays, the commitment of the Algerian government to develop beekeeping and the attractiveness of bee products to obtain supplementary incomes contribute to increase the number of beehives and the professionalization of this sector. However, some challenges should be undertaken to continue fostering this activity in rural areas. One of the most critical is the absence of a legal framework for honey quality for trade and the competition on the conventional market with imported honey. Research on the plant resources and the characteristics of the honey obtained by honeybees provide useful information and knowledge for national government, entrepreneurs and beekeepers but also for international entities, control labs, consumers, honey experts and other target groups.

There are about 4000 plant species distributed throughout Algeria (Véla and Benhouhou, 2007). Within this large diversity, flowering plants are the most diverse flora (Dobignard and Chatelain 2010-2013) and most of them are considered melliferous plants, those important for honeybees to produce honey (Koçyigit 2014). Some inventories of melliferous species have been carried out and published for different regions of Algeria, however, resources for honeybees remains poorly known compared to the plant biodiversity (Laallam et al 2011; Mekious et al 2016; Hamel and Boulamtafes 2017).

Babors Kabylia's region is considered a rich source of honey in North east of Algeria, due to its great floristic, faunal and environmental diversity, which makes it one of the most interesting regions in both biological and bio-geographical terms (Boutabia et al 2016).

Thus, the richness of the flora of the area has been deemed a biodiversity hotspot (Véla and Benhouhou 2007). In this context, pollination services help to maintain biodiversity being honeybees extremely efficient as pollinators. This is because they live in big colonies which leave 20 to 30 times a day to collect floral rewards, visiting 20 to 30 million flowers in one season and, as a result, they collect 10 to 1000 times more pollen in flowers than other insects (Dongock et al 2007).

The identification of the plants foraged by honeybees in an area is a key part to improve beekeeping management and to define the botanical profile of the honey produced in each region, thus avoiding the mislabeling of honey (Bhalchandra et al 2014). Moreover, authentication of bee products regarding botanical and geographical origin strongly depends on the knowledge about the bee resources in the area where were produced. Hence, this paper contributes to the knowledge of the flora visited by honeybees in a Mediterranean hotspot for plants, the region of Babors Kabylia (NE Algerie). In addition, melissopalynological analyses of honey samples collected from several apiaries were performed to evaluate the representation of the region's flora in the honey produced.

Materials and methods

The present study was carried out around 19 apiaries selected throughout the region and situated near to Bejaia, Draa El Gaid, Tichy, Aokas, Tizi N Berber, Lota, Souk El Tenine and Melbou (Figure 1).

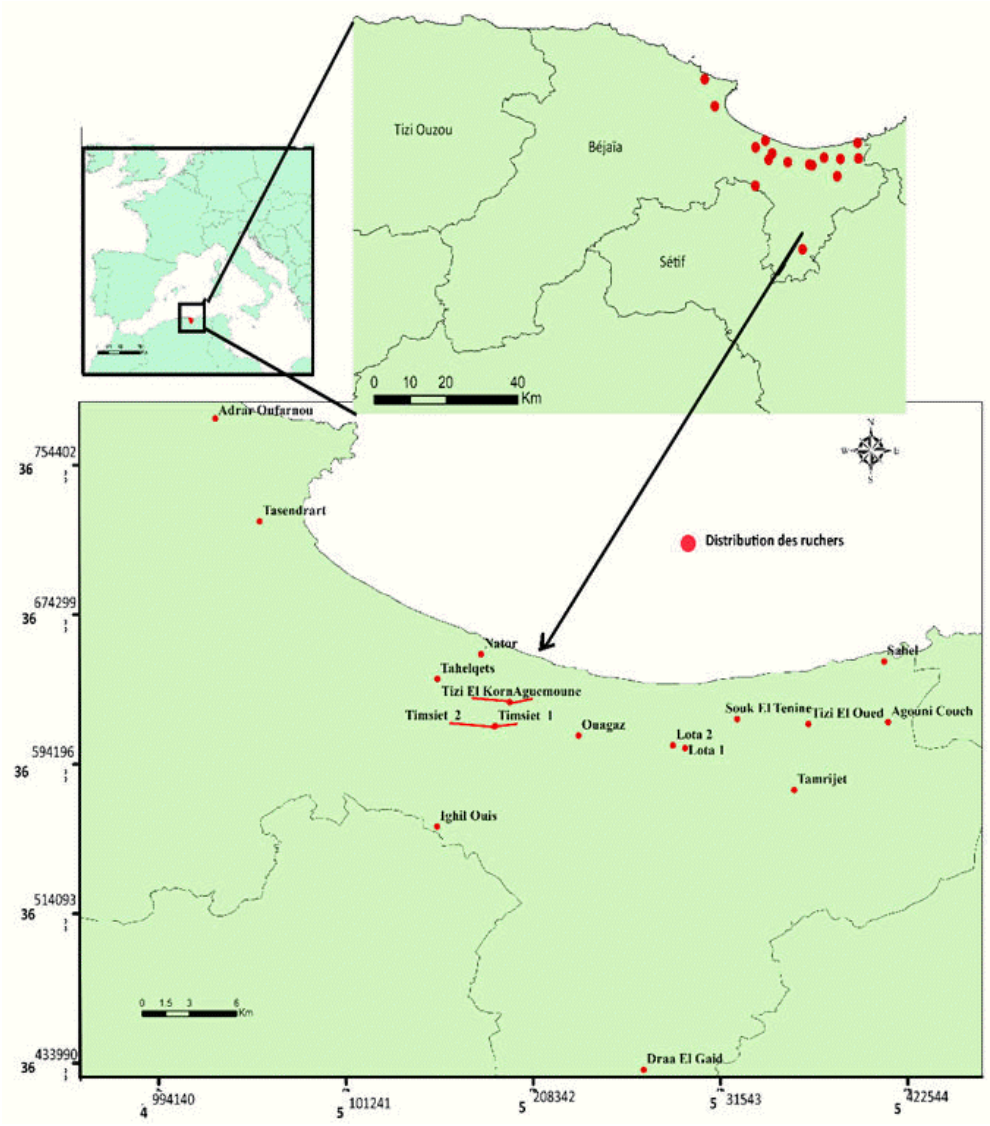

Figure 1. Location of sampled apiary stations

Characterization of the study area

The Babors Kabylia's region belongs to the biogeographical sector of the small Kabylia "K2" *sensu* (Quézel and Santa 1962-1963). It is a part of the Tellian mountain range, which crosses the Gulf of Bejaia and reaches Djbel Babor, located between the edge of the Mediterranean Sea and 2000 meters of altitude. It is characterized by a Mediterranean climate with a dry season between June and September and a rainy season mainly consisting of thunderstorms and torrential rains, concentrated during a very humid period from October to March with an annual average of nearly 900 mm/year. The nature of soil is mainly shisty and marly limestone which determines a typical xeric and sclerophic Mediterranean plant communities associated with low water and nutrient availabilities. The area is characterized for a vegetation formed by woodlands and shrublands, patched of spontaneous plants, agricultural fields and other grasslands and hedgerows, forming a relatively heterogeneous landscape with numerous forage opportunities for bees.

Forest formations are dominated by tall woody plants (greater than 4 m) covering near to 20% of the soil surface. The most representative are Aleppo pine (*Pinus halepensis* Mill.), *Eucalyptus* and the cork oak (*Quercus suber* L.) in the most humid places (northern exposure). Shrubland units represent alone more than half of the territory mainly as maquis, a low woody formation whose shrub layer height does not exceed 4 m. It is dominated by a multitude of species including *Cistus monspeliensis, C. salviifolius* L., *Erica arborea* L., *Phillyrea angustifolia* L., *Pistacia lentiscus*, *Calicotome spinosa* and *Myrtus communis* at low altitude.

Two types of riparian vegetation are encountered, the riparian forest of the Soummam, Oued Agrioun, Oued Zitouna, Oued Djemaa and their affluents dominated by *Populus alba* L. and *P. nigra* L., *Salix alba* L., *S. cinerea* L., *Tamarix aphylla* (L.) H. Karst., *Rubus ulmifolius* Schott., *Phragmites communis*, *Alnus glutinosa* (L.) Gaertn and in places *Fraxinus angustifolia* Vahl. The main cultivated area is near to the coast and generally, there are crops such as tomatoes, peppers, potatoes, cabbage flowers and several cultivated fruit trees.

Apiaries and sampling method

The quasi-totality of the apiaries are located at low altitude less than 600 m of altitude in inland regions. The floristic inventory was initiated by an exploration of all study areas from spring 2018 to spring 2019. Each apiary was considered as a sampling spot with a radius of two to three

kilometers around the installed hives, which is the average distance for bees foraging. Geolocation of the sites was done with a GPS (Garmin 78S) to carry out the topographic and geographic survey, and the ArcGIS version 10.5 software was used to produce the map (Figure 1).

Visual observations were done several times during all the year and the plants whose flowers were visited by bees for at least 3 minutes were listed. If the bee carried pollen, the plant was considered a pollen producer and when the bee visited the depth of the corolla, it was assumed a nectariferous plant. Plants were identified using the flora of Quézel and Santa (1962-1963) and the nomenclature was revised by the synonymic appendix of the flora of North Africa (Dobignard and Chatelain 2010-2013). In addition, an interview with beekeepers helped to complete the list of the harvested plants. The collected data was recorded in Microsoft Excel file that was used for the analysis.

The collection of the 27 honey samples studied was directly from the beekeepers during the spring and summer seasons (2018-2019) and the extraction of honey from the combs was done by centrifugation. After that, the samples were stored in glass jars at -4 ◦C until analysis.

Melissopalynological analysis

The pollen analysis of the samples is based on the methods of melissopalynology (Louveaux et al 1978). Ten grams of honey were dissolved in 30 ml of warm distilled water (less than 40 ◦C). The solution was centrifuged for 10 min at 4500 rpm and the supernatant was discarded. After that, 30 ml of distilled water was added, the solution was mixed and then centrifuged for 5 min discarding the supernatant. After vortexing, two drops (100 µL each) of sediment were placed on a slide and spread over two areas of approximately 24 × 24 mm. The pollen was examined using an optical microscope (OLYMPUS BX50) (400× or 1000× as appropriate).

The pollen grains were classified considering the accuracy of the identification. In the case of the pollen grain was identified as a particular species it was named with the scientific name of the species, in the case of the pollen grains corresponded to some species of a genus, the name used was the name of the genus and when the pollen grains had a similar morphology for some species and genus and even botanical families, it was used the nomenclature pollen type. Therefore, a pollen type represents a group of plants which pollen grains have similar morphology at optical microscopy. A minimum of 500 pollen grains was counted to determine the representation of each pollen type in the samples (Persano-Oddo et al 2004). This information was used to calculate the frequency classes according to Louveaux et al (1978).

Relationships among pollen types within the pollen spectra of the samples were tested using a Spearman rank correlation. The Spearman's correlation coefficient is a statistical measure of the strength of association of paired data. The positive correlation coefficient indicates a positive relationship between the two variables while a negative correlation coefficient expresses a negative relationship. The confidence level was $\alpha < 0.05$.

Results

Main melliferous species identified in the area

A total of 284 melliferous plants belonged to 60 botanical families were identified as used by the honeybees in the area (Tables 1 and 2). The most diverse families were Fabaceae (52 species, 18.3%), Asteraceae (35 species, 12.3%), Lamiaceae (33 species, 11.6%), Rosaceae (24 species, 8.4%), Apiaceae (14 species, 4.9%) and Boraginaceae (10 species, 3.5%). The remaining families were poorly represented (Figure 2).

Table 1. Main plant species identified in the area

Family	Plants in the area	Blooming
Fabaceae	*Anthyllis montana, A. vulneraria, Astragalus echinatus, Calicotome spinosa, Coronilla valentina, Cytisus villosus, Erinacea anthyllis, Genista ferox, G. numidica, G. tricuspidata, Hedysarum spinosissimum, Lotus angustissimus, L. corniculatus L. creticus, L. edulis, L subbiflorus, L. ornithopodioides, Lupinus angustifolius, Medicago lupulina, M. orbicularis, M. italica, Onobrychis caput-galli, Ononis aragonensis, O. hispida, O. natrix, O. viscosa, Retama sphaerocarpa, Scorpiurus muricatus, S. vermiculatus, Securigera atlantica, Spartium junceum, Teline monspessulana, Tetragonolobus biflorus, T. purpureus, Trifolium campestre, T. pratense, T. repens, T. resupinatum, T. squarrosum, Tripodion tetraphyllum, Vicia lathyroides, V. ochroleuca, V. onobrychioides, V. sativa*	Spring-Summer
	Acacia karroo, A. saligna, Hedysarum coronarium, Medicago polymorpha, Melilotus albus, M. sulcatus	Summer-Autumn
Asteraceae	*Anthemis cretica, Bellis annua, Calendula suffruticosa, Carduus pycnocephalus, Centaurea sicula, C. pullata, Helminthotheca aculeata, Pallenis spinosa, Plagius maghrebinus, Reichardia picroides, Scolymus grandiflorus, Urospermum dalechampii*	Spring-Summer
	Andryala integrifolia, Artemisia absinthium, Carduus nutans, Carlina gummifera, Cichorium intybus, C. pumilum, Dittrichia viscosa, Echinops spinosissimus, Galactites tomentosa, Glebionis coronaria, G. segetum, Helianthus annuus, Helichrysum lacteum, H. stoechas,Inula montana, Phagnalon saxatile, Helminthotheca echioides, Pulicaria dysenterica, P. odora, Scolymus hispanicus, Solidago virgaurea.Aster linosyris, Tripolium pannonicum	Summer-Autumn
Lamiaceae	*Ajuga iva, Lavandula stoechas, Lamium flexuosum, L. purpureum, Marrubium vulgare, Mentha suaveolens, Rosmarinus officinalis, Salvia verbenaca, Teucrium chamaedrys, T. flavum, T. polium, T. pseudochamaepitys, Thymus munbyanus subsp. ciliatus*	Spring
	Acinos alpinus subsp meridionalis, Calamintha nepeta, Clinopodium vulgare, Melissa officinalis, Mentha pulegium, Origanum vulgare subsp. glandulosum, Phlomis bovei, Prunella laciniata, P. vulgaris, Salvia phlomoides, S. sclarea, Stachys ocymastrum, S. officinalis, Teucrium scorodonia, Thymus algeriensis, T. numidicus, T willdenowii, Vitex agnus-castus	Summer
Rosaceae	*Amelanchier ovalis, Cotoneaster racemiflora, Crataegus azarolus, C. laciniata, C. monogyna, C. oxyacantha, Potentilla micrantha,Prunus avium, P. insititia, P. prostrata, P. spinosa, Rosa canina, R. sempervirens, Sorbus aria, Sorbus torminalis*	Spring-Summer
	Eriobotrya japonica, Potentilla caulescens, P. recta, P. reptans, Rosa sicula, Rubus incanescens, R. ulmifolius, Sanguisorba minor	Summer-Autumn
Boraginaceae	*Anchusa italica, Borago officinalis, Cerinthe major, Cynoglossum cheirifolium, C. creticum, C. gymnandrum, Echium italicum, E. plantagineum*	Spring

Brassicaceae	*Alliaria petiolata, Brassica napus, Sinapis alba, S. arvensis, S. pubescens, Sisymbrium officinale*	Spring
Apiaceae	*Athamanta sicula, Daucus carota, Smyrnium olusatrum, S. perfoliatum, Thapsia garganica*	Spring-Summer
	Ammi majus, Eryngium tricuspidatum, Ferula communis, Ferulago lutea, Foeniculum vulgare, Helosciadium nodiflorum, Pimpinella battandieri, P. tragium	May-September
Campanulaceae	*Campanula alata, C erinus, C dichotoma, C rapunculus*	Spring
	Campanula jurjurensis, C. trachelium, Jasione crispa	Summer
Convolvulaceae	*Convolvulus althaeoides, C. arvensis, C. cantabrica, C. tricolor*	Spring
Ericaceae	*Erica arborea, E. scoparia*	Spring
	E. multiflora	Summer
Myrtaceae	*Eucalyptus camaldulensis, E. globulus, Myrtus communis.*	Summer-Autumn
Other	*Gladiolus italicus, Moraea sisyrinchium, Iris unguicularis, Romulea bulbocodium. Linum corymbiferum, L. numidicus, L. usitatissimum, Salix alba, S. pedicellata, S.cinerea, Hypericum perfoliatum, H. tomentosum, Malope malacoides, Rhamnus alaternus, Ziziphus lotus, Centranthus ruber, Valeriana tuberosa, Antirrhinum majus, Scrophularia canina, Allium roseum, Asphodelus ramosus, Capparis spinosa, Coriaria myrtifolia, Fumaria capreolata, Centaurium erythraea,Juglans regia, Punica granatum, Oxalis pes-caprae, Reseda alba, Ribes petraeum, Ailanthus altissima, Tamarix aphylla, Daphne gnidium, Sambucus nigra, Laurus nobilis, Lomelosia crenata, Malva arborea, Vitis vinifera.*	Spring-Summer
	Knautia mauritanica, Sambucus ebulus, Cucurbita moschata, C. pepo, Cephalaria mauritanica, Dipsacus fullonum, Clematis flammula, Nigella damascena, Chamaerops humilis, Asparagus acutifolius, Berberis hispanica, Onosma fastigiata, Euphorbia falcata, Hypericum humifusum, Lythrum junceum, Malva sylvestris, Armeria alliacea, Scrophularia laevigata, Smilax aspera, Thymelaea hirsuta, Verbena officinalis	Summer

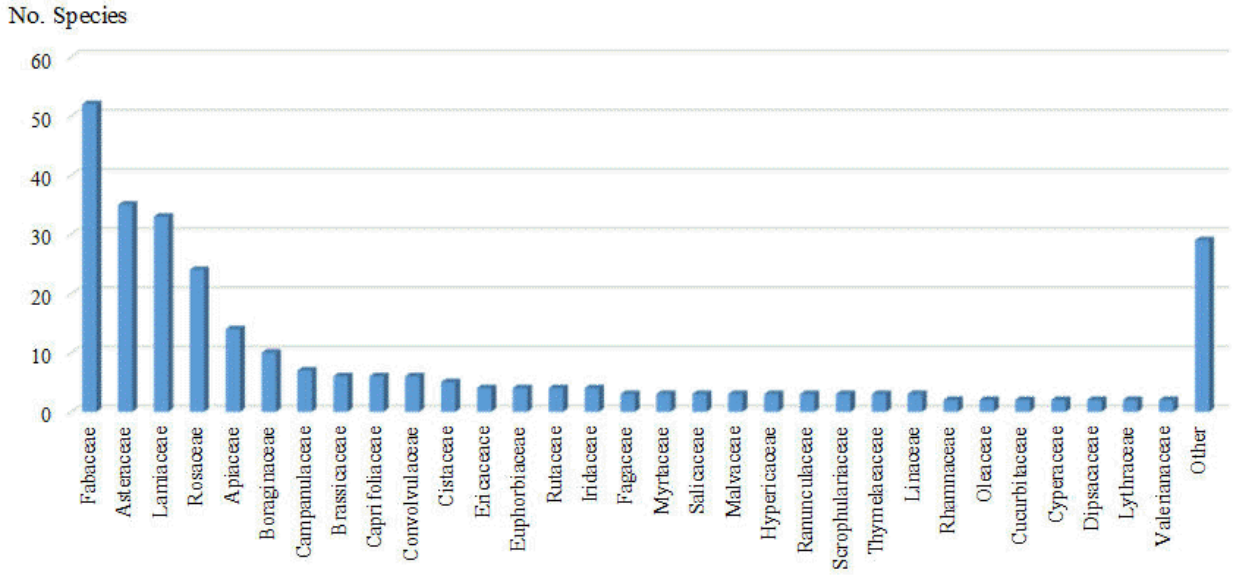

Figure 2. Number of species of each family identified in the study area

The most representative taxa of Fabaceae family, were *Genista* (*G. tricuspidata* Desf., *G. ferox* (Poir.) Dum. Cours. and *G. numidica* Spach.), *Trifolium* (*T. repens*, *T. campestre* Schreb., *T. pratense*), *Lotus* (*L. edulis*, *L. corniculatus, L. subbiflorus* Lag. and *L. ornithopodioides*) and *Ononis* (*O. natrix* L., *O. hispida* and *O. viscosa* L.). Other important plants like *Hedysarum coronarium*, *Calicotome spinosa*, *Erinacea anthyllis* Link., *Retama sphaerocarpa* and *Spartium junceum* were also present. For Asteraceae, the most common species were *Cichorium intybus*, *Bellis* (*B. annua* L. and *B. sylvestris* Cirillo), *Carduus* (*C. pycnocephalus* L. and *C. nutans* L.), *Glebionis segetum* (L.) Fourr., *Helichrysum stoechas* (L.) Moench., *Calendula arvensis* (Vaill.) L., *Solidago virgaurea* L., *Galactites tomentosa* and *Helminthotheca echioides* (L.) Holub. While for Lamiaceae family, *Stachys* (*S. officinalis* (L.) *Trevis.,* and *S ocymastrum* (L.) Briq.), *Teucrium* (*T. polium* L., *T. chamaedrys* L., *T. flavum* L., *T. scorodonia* L. and *T. pseudochamaepitys* L.) and *Lamium* (*L. purpureum* L., *L. flexuosum* Ten. and *L. amplexicaule* L.) were very common in the area, in addition to *Thymus munbyanus* subsp. *ciliatus* (Desf.) Greuter & Burdet and *Lavandula stoechas* L.

Daucus carota L., *Pimpinella tragium* Vill., *Foeniculum vulgare* Mill., *Eryngium tricuspidatum* L., *Ferula communis* L., *Ammi majus* L. and *Helosciadium nodiflorum* (L.) W. D. J. Koch are the most common species of Apiaceae family in the study area. For Rosaceae, *Crataegus* genus such as *C. monogyna* Jacq. and *C. oxyacantha* L., in addition to *Prunus avium* (L), *Rosa sempervirens* L., *Rubus ulmifolius* L. and *Pyrus communis* L. were the most abundant. Other well distributed taxa are also important for honeybees highlighting *Erica* genus represented by *Erica arborea* L., *E. multiflora* L. and *E. scoparia* L., *Pistacia lentiscus*, *Myrtus communis*, and *Eucalyptus* as well. (Photo 1.)

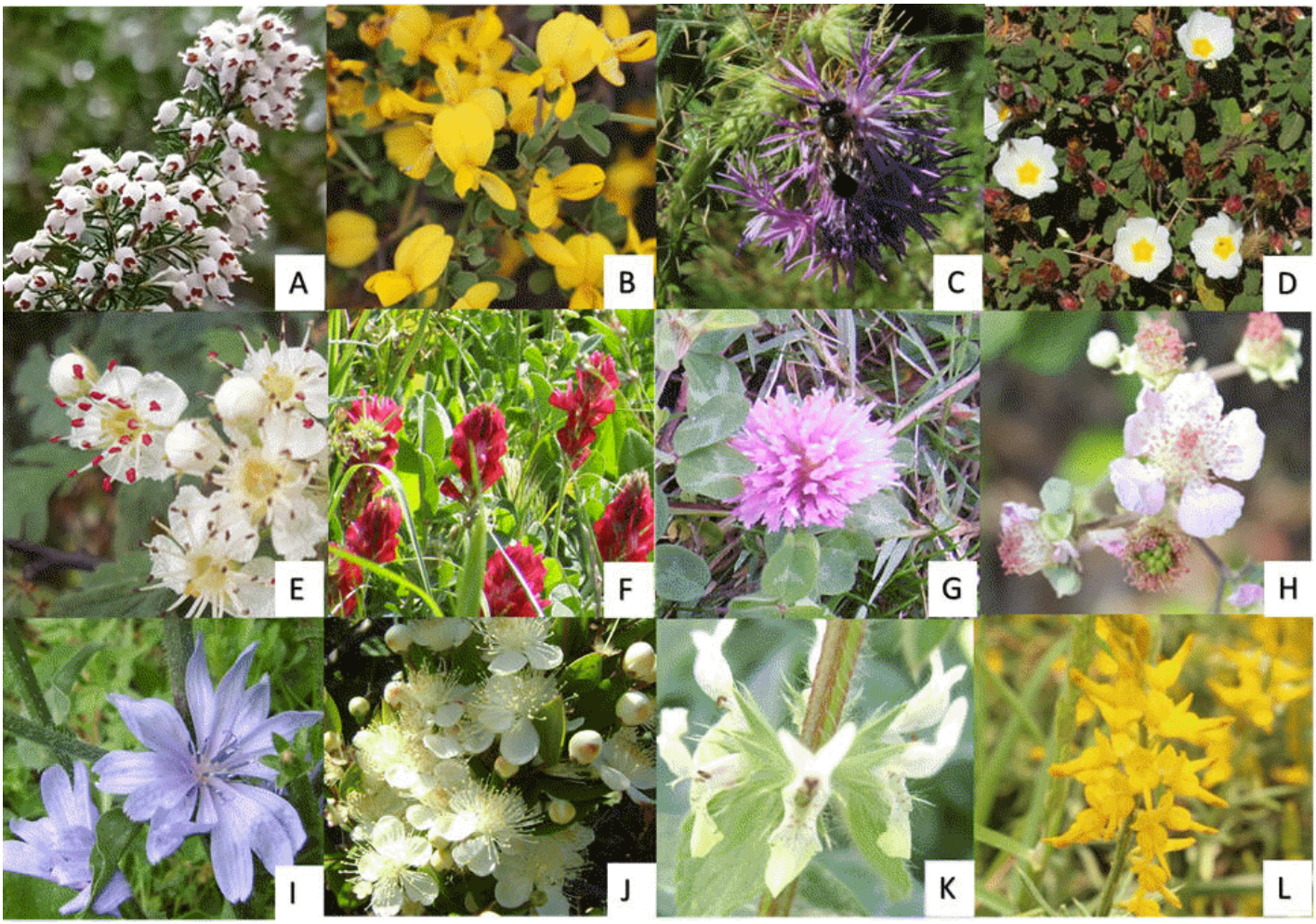

Photo 1. Photographic illustrations of some melliferous plants from Babors Kabylia's region. A: *Erica arborea*; B:*Calicotome spinosa*; C: *Galactites tomentosa*; D: *Cistus salviifolius*; E: *Crataegus laciniata*;
F: *Hedysarum coronarium*; G: *Trifolium pratense*; H: *Rubus ulmifolius*; I: *Cichorium intybus*; J: *Myrtus communis*; K: *Stachys ocymastrum*; L *Genista tricuspidata.*

Besides to all these, many species were exclusively polliniferous, providing pollen to bees without producing nectar (Table 2).

Table 2. Polliniferous species.

Family	Species	Blooming season
Cistaceae	*Cistus albidus, C monspeliensis, C salviifolius, Helianthemum helianthemoides, Tuberaria lignosa*	Spring-Summer
Fagaceae	*Quercus canariensis, Q. ilex, Q. suber*	Spring
Anacardiaceae	*Pistacia lentiscus*	Spring
Buxaceae	*Buxus sempervirens*	Spring
Cupressaceae	*Cupressus sempervirens*	Spring
Cyperaceae	*Carex extensa, Carex sylvatica*	Spring-Summer
Papaveraceae	*Papaver rhoeas*	Spring-Summer
Chenopodiaceae	*Chenopodium album*	Summer-Autumn
Crassulaceae	*Sedum album*	Summer
Salicaceae	*Populus tremula*	Spring
Oleaceae	*Fraxinus angustifolia, Olea europaea*	Summer

Blooming period

The large number of flowering plants started the blooming in spring. About 168 species were identified during this period, mainly from the Fabaceae family (44 species), Rosaceae (15 species), Lamiaceae (13 species), Asteraceae (12) and Boraginaceae (9). However, the summer period, also includes a considerable number of flowering plants (about 97 species) mainly from Asteraceae family (23 species), 18 species of Lamiaceae, 9 and 8 of Apiaceae and Rosaceae respectively (Table 1). The remaining species, which constitute annual and wintery species, belong mainly to the families Euphorbiaceae and Rutaceae.

Biological type

Melliferous species were classified considering their plant life-form. Among the biological types defined by Raunkiaer (1905), the categories used were:

- Phanerophytes: perennial woody plants (trees or shrubs) whose buds are located more than 50 cm above ground level. The Nano, Meso and Micro subtypes are relative to the height of the plants.

- Chamephytes: herbaceous or more or less lignified plants, whose buds are less than 50 cm from the ground.

- Hemicryptophytes: herbaceous perennial plants, or biennial, whose buds are at ground level.

- Geophytes: biennial or perennial herbaceous plants, spending the bad season as bulbs, rhizomes or tubers.

- Therophytes: annual plants, spending the bad season in the seed state.

One hundred and eight plants were Hemicryptophytes (38.0%), 73 Therophytes (25.7%), 62 Phanerophyte (21.8% including Nanophanerophytes, Mesophanerophytes and Microphanerophytes), 34 Chamephytes (12.0%) and 7 Geophytes species (6.5%). Most Fabaceae, Boraginaceae and Brassicaceae plants were Therophytes (27, 8 and 5 species, respectively) while Asteraceae, Lamiaceae and Apiaceae plants were mainly Hemicryptophytes (29, 15 and 13 species respectively), however Rosaceae plants were predominantly Phanerophyte.

Flowers color

The results showed a diversity of colors within the melliferous plants, indicating a correlation with the observed floral biodiversity. Nine different flower colors were noted, the colors yellow, white and pink were the most representative (96, 78 and 47 species respectively) followed by the colors: blue purple and violet (21, 18 and 10 species respectively). Green, red and brown came last with a low number of species (8, 5 and 1 species respectively) (Figure 3).

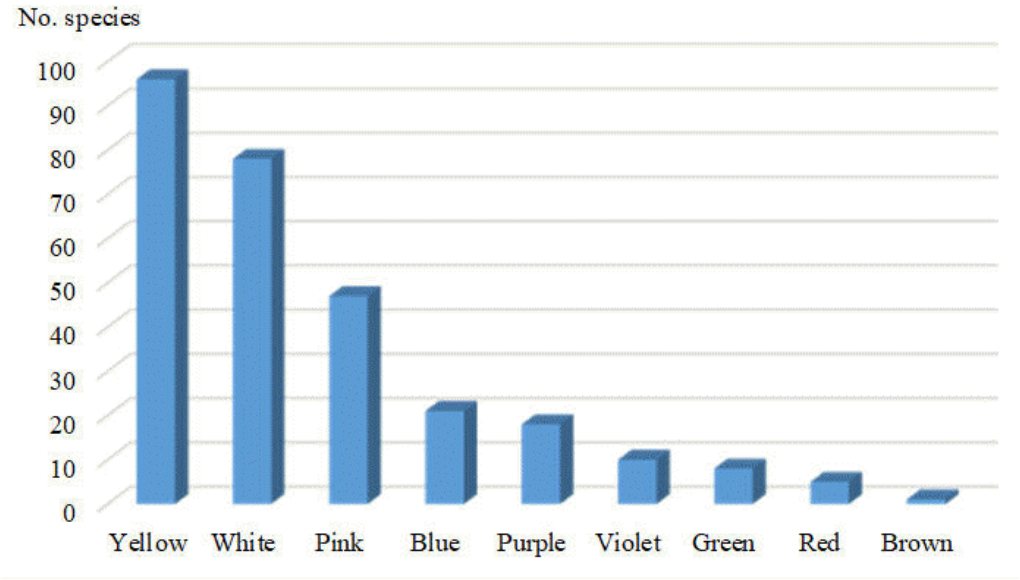

Figure 3. Flower colors of plants visited by honeybees

Melissopalynological analysis

The results from the qualitative pollen analysis are shown in Table 3, where the main pollen types identified in honeys (over 1%) and their corresponding frequencies for the different samples are indicated.

Table 3. Main pollen types identified in the honey samples produced in the area.

Family	Pollen type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Amaryllidaceae	*Allium*	-	-	P	-	P	P	-	-	-	-	P	-	-	-	P	-	P	P	-	P	-	-	P	-	-	-	I
Anacardiaceae	*Pistacia lentiscus*	I	-	-	-	I	I	-	P	-	P	R	P	P	I	R	R	R	A	-	P	-	I	I	I	P	-	A
Apiaceae	*Daucus carota* t.	-	-	-	-	-	-	-	-	-	-	I	I	R	P	-	-	-	-	P	-	R	-	-	-	-	-	-
	Eryngium t.	-	P	-	P	-	-	-	-	-	-	-	P	P	P	-	-	P	-	-	P	P	-	-	-	-	P	R
	Foeniculum t.	P	R	I	I	I	R	I	-	P	P	R	-	P	R	-	P	I	P	-	P	R	-	P	R	-	P	P
	Pimpinella t.	P	R	R	-	I	-	R	-	P	-	I	I	R	-	-	P	P	R	-	P	P	-	P	-	-	-	-
Arecaceae	*Chamaerops*	-	-	-	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Asteraceae	*Aster* t.	R	-	I	I	R	-	P	R	A	P	R	I	R	P	-	-	-	-	-	P	-	-	-	-	-	-	-
	Bellis t.	-	-	P	R	P	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Chrysanthemum t.	P	-	-	R	P	P	P	-	P	P	R	-	P	P	-	-	R	-	-	-	-	-	P	-	-	-	-
	Cichorium t.	P	-	-	-	P	P	-	P	P	-	-	P	-	-	-	P	-	-	-	P	P	-	P	P	P	P	-
	Galactites t.	P	I	R	-	R	I	R	-	I	P	P	P	P	-	P	-	P	P	P	P	-	P	P	-	P	P	-
	Other *Asteraceae*	-	-	R	-	-	P	-	-	-	-	R	P	P	-	P	P	P	-	-	-	-	-	-	-	-	-	-
Boraginaceae	*Echium*	P	-	-	I	-	P	R	P	P	R	-	P	R	-	-	-	P	-	-	I	R	-	R	-	-	P	-
Brassicaceae	*Brassica* t.	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	P	P	-	-	-	-	-	-	-
	Other *Brassicaceae*	P	R	-	-	-	-	P	-	P	P	P	I	I	R	-	-	-	-	-	-	-	P	-	-	-	P	R
Capparaceae	*Capparis spinosa*	-	I	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	P	-	-	-	-	-	P
Cistaceae	*Cistus*	P	R	-	-	P	P	R	P	-	-	P	P	-	R	P	P	P	-	-	R	-	-	P	R	R	P	-
Coriaceae	*Coriaria*	-	-	-	-	P	-	-	-	-	-	-	-	-	R	-	P	-	-	-	-	-	-	-	R	R	R	-
Cyperaceae	*Carex* t.	-	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	P	-	R	-	P	-	I	-	-	-	-
Ericaceace	*Erica*	A	-	P	-	I	A	R	-	P	I	I	R	P	A	D	A	A	A	-	I	R	I	A	D	D	D	I
Euphorbiaceae	*Euphorbia*	P	R	P	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mercurialis	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabaceae	*Arachis hypogea* t.	-	P	-	R	-	-	R	I	P	-	P	-	R	-	-	-	P	-	-	-	P	-	-	-	-	-	-
	Astragalus t.	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ceratonia siliqua	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-
	Genista t.	A	R	I	I	I	I	P	I	I	-	I	A	A	A	A	D	A	A	P	A	I	D	A	A	A	A	A
	Hedysarum	R	A	A	A	I	-	D	I	I	P	I	P	I	R	-	-	-	-	D	R	I	P	-	-	-	P	-
	Lotus t.	P	R	R	I	P	R	P	R	P	P	-	P	R	P	-	-	-	-	I	P	I	P	I	-	P	-	-
	Spartium junceum	I	-	-	-	-	-	-	-	-	-	I	-	-	I	-	-	A	I	-	-	-	P	-	-	-	-	I
	Trifolium repens t.	P	A	I	I	P	R	R	I	I	P	I	I	I	I	P	-	P	P	R	I	I	P	-	P	P	P	-
	Other *Fabaceae*	I	R	I	I	-	I	P	-	I	-	-	-	-	I	-	-	-	-	-	-	R	-	-	-	-	-	-

Fagaceae	*Quercus*	-	-	R	-	P	P	-	-	P	-	-	-	-	R	-	-	-	I	-	P	P	P	I	-	-	-	-
Lamiaceae	*Stachys* t.	I	R	I	P	P	-	R	I	I	-	R	I	P	-	-	R	-	P	-	I	P	P	P	R	R	I	-
Lythraceae	*Lythrum*	-	-	-	I	-	-	-	I	-	-	-	P	-	-	-	-	-	-	-	-	P	-	P	-	-	-	-
	Punica granatum	-	R	-	-	-	-	R	I	-	P	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Myrtaceae	*Eucalyptus*	P	P	R	-	R	-	R	-	I	-	R	-	I	-	-	P	P	-	-	I	A	-	I	-	-	-	-
	Myrtus	I	-	I	-	A	A	I	-	I	A	I	I	I	R	P	P	I	I	P	I	-	R	I	R	P	R	-
Nitrariaceae	*Peganum harmala*	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oleaceae	*Fraxinus*	p	-	-	R	P	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	P	-	-	R	P	P	-
	Olea europaea	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	P	-	I	-	-	-	-	-	-	-	-
Papaveraceae	*Papaver*	-	P	-	-	-	P	-	R	-	P	-	P	P	-	-	-	-	-	-	-	-	-	P	-	-	-	-
Plantaginaceae	*Plantago*	-	-	-	-	-	-	P	-	-	-	-	P	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhamnaceae	*Rhamnus alaternus*	p	-	-	-	-	P	-	-	P	-	-	-	-	R	-	-	-	-	-	P	-	-	P	-	-	-	-
Rosaceae	*Crataegus* t.	-	I	I	-	P	P	-	-	-	-	-	-	-	I	-	-	-	-	-	R	-	-	-	-	-	-	-
	Prunus t.	-	P	-	P	-	R	-	-	P	-	P	-	P	-	-	-	-	P	-	I	-	-	P	-	-	-	-
	Rubus	P	R	P	I	R	P	-	I	R	D	I	P	R	-	P	R	R	-	-	R	P	P	R	-	-	-	P
	Other *Rosaceae*	R	R	-	-	-	R	I	-	R	-	-	I	I	-	-	-	I	-	P	I	I	P	-	-	-	P	R
Rutaceae	*Citrus*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Salicaceae	*Salix alba*	I	-	-	-	R	P	-	-	-	-	P	-	-	I	P	I	P	-	-	-	I	-	P	-	-	-	-
Tamaricaceae	*Tamarix*	-	R	-	-	-	-	-	-	-	-	-	-	P	-	-	P	-	-	I	-	-	-	-	-	-	-	-

A: accompanying pollen, D: dominant pollen, I: important pollen, P: present pollen, R: rare pollen

Eighty-eight (88) different pollen types belonging to 44 families were identified in the pollen spectrum of the honey samples, including 71 nectariferous taxa and 17 polliniferous taxa. The samples had a high diversity of pollen types, with an average value of 24, although 7 samples had more than 30 different pollen types. The best represented botanical families were Fabaceae (11 different types), Asteraceae (8 types), Apiaceae (7 types), Lamiaceae (6 types) and Rosaceae and Boraginaceae (4 types) providing the 45.5% of the pollen types.

Among the Fabaceae, which represented 12.5% of the types identified, *Genista* and *Hedysarum* were the most frequent pollen types. The first was present in 96.3% of the samples and the second in 66.7% of them. *Genista* type was dominant in two samples with a maximum value of 73.9% and was found to be a secondary and important pollen type in 48.2% and 29.6% of the samples, respectively. While *Hedysarum* type was dominant in two samples and had a maximum value of 73.5% and was present as an important pollen type in 22.2% of samples.

For Asteraceae plants, *Galactites* type was found in 74% of the samples mainly as present pollen (48.2%) and the values in samples did not exceed 7.3%, while *Aster* type was found in 48.2% of the honeys mainly as a minor and important pollen type and had a peak value of 39.7 % in the pollen spectra. The most frequent Lamiaceae pollen was *Stachys* type, found in 74% of samples mainly as minor or as present pollen having a maximum value of 9.7%. Apiaceae plants such as *Foeniculum* type and *Pimpinella* type were found in 77.8% and 55.6% of the samples, respectively, commonly as present, minor or scarcely as important pollen type. Finally, Rosaceae such as *Rubus* type was found in 74% of the samples but was dominant pollen type in one of them with a value of 58.7%, and Boraginaceae plants like *Echium* type were found in 51.9% of samples having a maximum value of 4.6%.

In addition, *Erica* type was represented by the species *E. arborea* and *E. multiflora*. This type of pollen was found in 85.2% of the samples and had a maximum value of 72.8%, being a dominant pollen in four samples and a secondary pollen in seven samples. Other plants represented in the pollen spectra of honeys were from Myrtaceae family like *Eucalyptus* and *Myrtus* that were secondary and minor pollen types in the samples, respectively. *Pistacia lentiscus* type was also present in 74% of the honey samples with values lower than 30% (minor or important pollen) but was secondary pollen in two samples.

The pollen spectra of the samples showed that some pollen types appeared together. Therefore, a correlation analysis has been carried out to show the relationships between them and their statistical significance, the most relevant are showed in Table 4. Positive correlation coefficients mark the pollen types that appeared at the same time in the pollen spectra. This occurs when the pollen producing plants share the plant community and bloom at the same time. Thus, a positive and significant correlation (p <0.01) has been found between the pollen type *Erica* and *Genista* and *Pistacia lentiscus*. Also, *Myrtus communis* had a positive correlation with some herbaceous plants from the Asteraceae family as in the *Aster* t. (p <0.05) and *Galactites* t. (p <0.01). *Myrtus communis* also had a positive correlation with *Pimpinella* pollen type (p<0.01). *Eucalyptus* appeared together with some plants of Apiaceae as those in *Foeniculum* type (p <0.01) and *Pimpinella* type (p <0.01), but also with *Rubus* (p <0.05). This last pollen grain appeared in samples with pollen grains of *Aster* type, *Echium* and *Prunus* type as well as *Eucalyptus* . On the other side, *Hedysarum* had a positive correlation with pollen from other herbaceous plants such as *Trifolium repens* pollen type, *Lotus* pollen type or *Aster* pollen type. *Galactites* and *Aster* pollen types had a positive correlation (p <0.01) among them and with *Pimpinella* pollen type (p <0.01) and *Myrtus* (p <0.01). In addition, *Aster* pollen type had a positive correlation with *Stachys* type (p <0.05) and *Rubus* pollen (p <0.01). Lastly, *Echium* presented a positive correlation with *Lotus* type (p <0.01) and *Rubus* (p <0.01). The negative correlation coefficients identify the pollen types of honeys produced in different areas. The most relevant negative correlations were found between *Erica* pollen and *Hedysarum*, *Trifolium* repens, *Lotus* and *Aster* pollen types (p <0.01). Finally, a negative correlation was found with herbaceous plants as *Hedysarum* and *Trifolium repens* type and *Genista* type and *Ceratonia* (p <0.01). This is due the samples which had more content in *Erica* pollen do not contain *Hedysarum* or present *Hedysarum* in low quantities. However, *Hedysarum* pollen type appeared commonly with other herbaceous Fabaceae plants (as *Lotus*) or Asteraceae (*Aster*, *Galactites*). The identified relationships are useful to the authentication of honey regarding both botanical origin and geographical origin.

Table 4. Coefficients of the Spearman correlation analysis for the relevant pollen types

Variables	*Erica*	*Pistacia lentiscus*	*Myrtus*	*Eucalyptus*	*Rubus*	*Hedysarum*	*Trifolium repens* t	*Galactites t*	*Aster t*	*Echium*
Genista t	0.495	0.624	-0.014	-0.031	-0.131	-0.626	-0.492	-0.325	-0.227	-0.144
Erica		0.586	0.096	-0.306	-0.388	-0.829	-0.711	-0.252	-0.570	-0.322
Pistacia lentiscus	0.586		0.146	-0.237	-0.180	-0.647	-0.665	-0.226	-0.322	-0.403
Myrtus	0.096	0.146		0.211	0.258	-0.028	0.105	0.662	0.384	0.151
Quercus	0.032	0.253	0.283	0.275	-0.094	-0.074	-0.035	0.164	0.021	0.042
Ceratonia siliqua	-0.020	0.177	0.324	0.297	0.165	0.163	0.061	0.121	0.175	0.130
Eucalyptus	-0.306	-0.237	0.211		0.391	0.327	0.273	0.303	0.278	0.356
Hedysarum	-0.829	-0.647	-0.028	0.327	0.217		0.769	0.297	0.620	0.205
Aster t	-0.570	-0.322	0.384	0.278	0.535	0.620	0.678	0.312		0.342
Astragalus	-0.290	-0.077	-0.278	-0.176	0.254	0.205	0.176	-0.254	0.190	0.160
Trifolium repens t	-0.711	-0.665	0.105	0.273	0.348	0.769		0.384	0.678	0.275
Stachys t	-0.223	-0.375	-0.015	0.190	0.024	0.327	0.401	0.124	0.469	0.148
Foeniculum t	-0.180	-0.213	0.288	0.433	0.235	0.345	0.310	0.338	0.218	0.149

Lotus t	-0.678	-0.538	-0.167	0.371	0.190	0.610	0.524	0.134	0.307	0.465
Galactites t	-0.252	-0.226	0.662	0.303	0.194	0.297	0.384		0.312	0.042
Pimpinella t	-0.336	-0.124	0.501	0.677	0.278	0.330	0.391	0.550	0.421	0.087
Echium	-0.322	-0.403	0.151	0.356	0.442	0.205	0.275	0.042	0.342	
Prunus t	-0.251	-0.035	0.236	0.362	0.403	0.082	0.329	0.306	0.209	0.350
Rubus	-0.388	-0.180	0.258	0.391	1	0.217	0.348	0.194	0.535	0.442

Discussion

The area had a remarkable species richness with different habitats created by the particular orography, the climate and the human intervention. This diversity plays a major role in providing high quality forage for both livestock and wild animals, supporting insect communities for pollination services, among them, the honeybees (Guarino et al 2020).

Hence, this diversity is important to sustain beekeeping activity and honey production being an opportunity for the economy of rural communities. It was denoted the existence of forage resources during all year. Most of the nectariferous plants were present during spring and summer but during winter some Euphorbiaceae and Rutaceae, mainly *Citrus* trees contribute to the maintenance of the honeybees and provide pollen resources for bee brood.

Most of the identified plants used by honeybees were spontaneous species confirming the high melliferous potential of wild flora for beekeeping. The main taxa were heathers (*Erica*), broom plants (*Genista*, *Cytisus*, *Spartium*, *Retama*), Sulla (*Hedysarum*) and other herbaceous species from Fabaceae, Apiaceae, and Asteraceae families as (*Astragalus, Trifolium, Foeniculum, Pimpinella, Daucus, Aster* or *Galactites*). These plants have been mentioned for their contribution to honey production in other studies about pollen composition of Algerian honey (Chefrour et al 2009; Nair et al 2013; Haderbache et al 2013; Draiaia 2014; Zerrouk et al 2014; Makhloufi et al 2015; Ghorab et al 2021).

Biodiversity of the area and honey production

Different plant associations mainly shrublands and lesser forest and grasslands can be found but the most representative for beekeeping are the first. The lowest altitudes of mountainous areas are dominated by the maquis, one of the characteristic shrubland of Mediterranean areas, it represents, together the suberaie, the most widespread and diversified plant formation of the territory. It is the result of the degradation of the subaerial forest and abandoned lands, mainly due to recurrent fires. The maquis is composed by several small and medium-sized evergreen sclerophyllous plants together small trees constituting the main plant community for beekeeping. Different elements of this shrubland were visited by the honeybees and their pollen grains have been found in the collected honey. It should be highlighted Ericaceae plants with *Erica arborea, E. multiflora* and *E. scoparia* in association with broom species represented in pollen as *Genista* type. These plants grow on acidic soils frequently over deforested areas as first seral stages, mostly linked to locally humid and cool mesoclimatic conditions (Guarino et al 2020). *Erica* appeared with values higher than 15% in 11 of the 27 honey samples collected whereas in 6 was found as important pollen (3-15% of the pollen spectra) and was present in 88.8% samples. This supports the importance of this plant for honey production in Mediterranean areas (Yang et al 2012).

Furthermore, Fabaceae family is highly appreciated by bees, especially for its good nectar and pollen production and long flowering period (Cencetti et al 2019), as well as for the diversity of extrafloral nectaries located on the plant (Marazzi et al 2019). In the case of Cytiseae species, the apicultural value is discussed as some of them are considered good nectar sources, for example *Retama sphaerocarpa* or *Spartocytisus supranubius* (L.f.) Christ ex G. Kunkel (Persano-Oddo et al 2004; Serra-Bonvehi et al 2004), whereas other are considered nectarless plants, such as *Calicotome spinosa*. Due to the fact that the pollen grains from these taxa have similar pollen shape, and are frequently identified as *Genista* or *Cytisus* pollen type. The most abundant species in the area were *Genista tricuspidata*,*Genista numidica*, *Genista ferox*, *Cytisus villosus*, *Erinacea anthyllis* and *Retama sphaerocarpa*. For all of them the insects are the main pollinators and pollen seems to be the main floral reward, but nectar production was confirmed for most of the species (Galloni and Cristofolini 2003). The pollen type was very frequent (present in 96.3% of samples) and reached values higher than 15% in 15 samples while in 8 samples was important pollen. Hence, more studies about the apicultural interest of these plants are required. The same occurs with *Spartium junceum* found in 6 honey samples with values higher than 3% of the pollen spectra.

Other elements in the thermophilic facies of the maquis such as *Myrtus communis* and *Pistacia lentiscus* appeared well represented in honey samples. *Myrtus communis* had a high apicultural value being mentioned as good honey producer (Yang et al 2012; Yang et al 2014; Cenet 2019). On the contrary, *Pistacia lentiscus* is an anemophilous plant that is considered to provide uniquely pollen for honeybees.

At lower altitudes the thermo-Mediterranean, sub-littoral to semi-continental character originates a vegetation complex characterized by a small shrubland in which predominates Lamiaceae such as *Stachys ocymastrum*, *Lavandula stoechas*, *Thymus munbyanus* and *Teucrium polium.* The best-represented pollen type in samples was *Stachys,* a group for plants such as *Stachys ocymastrum*, *Stachys officinalis*, *Phlomis bovei* Noë and *Vitex agnus-castus, Lamium flexuosum* Ten. and *L. purpureum* L. (Valdés et al 1987). Other species of this family such as *Teucrium* type or *Thymus* type were found in the pollen spectrum of honey but with lower representation (<1%). Considering that Lamiaceae plants often appeared like under-represented pollen in honey samples, the contribution of these plants for apiculture should be more investigated. The mentioned species can be found together with Cistaceae (*Cistus salviifolius*, *C. monspeliensis*, *Helianthemum* and *Halimium* species) and some herbaceous Fabaceae (*Anthyllis vulneraria* L. *, Astragalus echinatus* Murray., *Ononis, Melilotus* species), some Asteraceae (*Anthemis cretica* L., *Calendula suffruticosa* Vahl., *Phagnalon saxatile* (L.) Cass.) or other plants as *Daphne gnidium* L., being also a good landscape for beekeeping practice. Pollen grains from these plants were found in most of the honey samples, mainly in those obtained in the early summer. The importance for the honey production of this garrigue-like Mediterranean vegetation was mentioned for other areas as Corsican and Italian regions (Yang et al 2012; Yang et al 2014; Silici and Gökceoglu 2007).

Special comment deserves to be highlighted, is the presence of certain species of forage legumes such as *Hedysarum, Trifolium, Medicago* or *Lotus*. Concretely some species of *Hedysarum* can be found in the area mainly (*H. spinosissimum* and *H. coronarium*). The first is found in more arid areas while *H. coronarium* is common in the northeast of the country on heavy soils in well-watered areas (Abdelguerfi-Berrekia et al 1991). These species are very important for honey production in the Mediterranean regions of Algeria (Zerrouk et al 2013; Boutabia et al 2016; Hamel and Boulamtafes 2017; Ghorab et al 2021).

In addition, Asteraceae plants such as *Bellis sylvestris*, *Glebionis segetum, Carduus pycnocephalus* and *Galactites tomentosa*, which bloom mainly during summer constitute an attractive source for bees. Similarly, Apiaceaae plants mainly represented by *Foeniculum vulgare*, *Daucus carota*, *Pimpinella battandieri* and *P. tragium* Vill., were identified in the area and in the honey samples for the presence of their pollen grains.

Regarding crops, the main cultivated area is near to the coast between Tichy and Melbou, and the wadis. The most relevant for honey production are represented by orange, lemon, apple and sometimes medlar trees. On both sides of the wadis, we find terraces still exploited and dominated by fruit

trees (Fig trees), olive trees (*Olea europaea* L.) and downstream vineyards (*Vitis vinifera* L.) which also contributes to the hive maintenance with pollen and nectar production or together (*Ficus carica* L.) with fruit secretions.

In addition, some Rosaceae species (*Malus domestica* Borkh.*, Eriobotrya japonica* (Thunb.) Lindl., *Prunus avium* and *Pyrus communis*) and some species citrus trees (*Citrus reticulata* Blanco., *Citrus limon* (L.) Burm., *Citrus ×sinensis* (L.) Osbeck, *Citrus ×aurantium* L.) provide year-round feeding resources for bees (Makhloufi et al 2015; Homrani et al 2020).

Most of these plants bloom at the same time, mostly during the spring, and constitute a good combination of pollen and nectar sources. Polliniferous species are also important for beekeeping because they provide the protein components to feed the brood. The most important were species of the taxa *Cistus*, *Quercus*, *Fraxinus*, *Papaver, Plantago*, *Carex*, *Olea europaea* and *Pistacia lentiscus.*

Our results showed a high diversity of melliferous species within the study area during almost the whole year but mainly during spring and summer. The number of species found was much higher than those found in other studies (Laallam et al 2011; Mekious et al 2016; Hamel and Boulamtafes 2017) conducted in the southwest, Edough Peninsula and northern Algeria (66 species 107 species and 103 species respectively). However, always the families Fabaceae, Asteraceae and Lamiaceae were mentioned as the main resources for beekeeping in the area (Véla and Benhouhou 2007; Boutabia et al 2016; Hamel and Boulamtafes 2017; Hamel et al 2019) and other North African countries as Tunisia (Mahouachi, 2008). This study also showed the importance of Ericaceae for honey production (Mekious et al 2016).

Biological type and flower color

The biological type classified the plants according to the survival organs during the bad season (the summer for the Mediterranean region). The permanent availability of floral resources throughout the year, diversified regarding to the biological type but the dominating of perennial plants (Hemicryptophytes) allows a continuous foraging activity. In addition, the presence of therophytes offers important rewards for insects. These plants characterized by a short life cycle, grow during the favorable season or after biotope perturbations as a result of the degradation of the plant cover. In the last case, plants that adapt easily to these degraded environments tend to appear, including ruderal plants, plants of global distribution or invasive species, among others *Oxalis pes-caprae* L. and *Convolvulus althaeoides* L. However, they are sensitive than other biological types especially to temperature conditions, because they are more likely to use resources in deep soils due to their root system, allowing them to develop a high floral potential (Grimau et al 2014; Hicks et al 2016). Most of the identified melliferous plants in the area were hemicryptophytes but in other regions, the most important were phanerophytes (Hamel and Boulamtafes 2017).

Honeybees forage particularly the available floral species around the site where the apiaries are installed, using visual cues for orientation, as long as they provide them with nectar and/or pollen. Despite having a relatively simple nervous system, bees can master color classification and consequently classify bluish and yellowish stimuli into different categories (Benard et al 2006). Our results were in accordance with those of Hamel et al (2019) in study on Numidia region reported that yellow color was strongly represented (35.4%), followed by white color (31.2%), then pink, blue and violet color came at last. In addition, Lobreau-Callen et al (1986) have stated that bees prefer light-colored flowers (white or yellowish) that emit attractive odors and secrete an abundant nectar rich in substances demanded by bees. The honeybees forage by choosing flowers that have a similar shape, color and smell (Chittka et al 1999). Therefore, the dominance of species of certain flower colors imposes on bees to go towards these flowers, so the variation in color can be only a reflection of the richness of biodiversity of the region (Hamel 2013).

Conclusion

- This study highlighted an important number of melliferous plants that were sources of nectar and pollen for the honeybees in Babors Kabylia's region.
- The wide diversity of nectar and pollen suppliers in the region corresponds to 60 families of which many of them are spontaneous plants.
- The biggest number of species belongs to the families: Fabaceae, Asteraceae, Lamiaceae, Rosaceae and Apiaceae. Being the most representative sources for honeybees together with *Erica* species.
- This richness in melliferous plants allows to ensure a considerable development and sustainability of beekeeping industry in the region.
- The pollen analysis of honey has enhanced this study, and helped to determine pollen spectrum of honeys produced in the area.
- To have a global idea of beekeeping in all the territories of the country and to understand the behavior and management of honeybees, it is essential to perform complementary studies in this field.

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References

Abdelguerfi-Berrekia R, Abdelguerfi A, Bounaga N and Guittonneau GG 1991 Répartition des espèces spontanées du genre *Hedysarum* selon certains facteurs du milieu en Algérie. Fourrages, 126, 187–207.

Benard J, Stach S and Giurfa M 2006 Categorization of visual stimuli in the honeybee Apis mellifera. 9 (4), 257-270. DOI: 10.1007/s10071-006-0032-9

Bhalchandra W, Baviskar R and Nikam T 2014 Diversity of nectariferous and polleniferous bee flora at Anjaneri and Dugarwadi hills of Western Ghats of Nasik district (MS) India. Journal of Entomology and Zoology Studies, 2(4), 244–249.

Bonvehi J S, Manzanares A B and Vilar J M S 2004 Quality evaluation of broom honey (*Spartocytisus supranubius* L.) produced in Tenerife (The Canary Islands). Journal of the Science of Food and Agriculture, 84(10), 1097–1104. DOI:10.1002/JSFA.1792

Boutabia L, Telailia S and Chefrour A 2016 Spectre pollinique de miels d'abeille (Apis mellifera L.) de la région d'El Tarf (Nord-Est algérien). Livestock Research for Rural Development, 28, 1–8.

Cencetti T, Lippi M M, Nombré I and Orioli L 2019 Pollen analysis of some Burkina Faso honey samples. Webbia. 74(2), 373–381. https://doi.org/10.1080/00837792.2019.1627455

Cenet M 2019 Pollen Analyses and Antimicrobial Properties of the Natural Honey from the East Mediterranean Part of Anatolia. Pakistan Journal of Zoology, 51(2), 541–548. DOI: http://dx.doi.org/10.17582/journal.pjz/2019.51.2.541.548

Chefrour C, Draiaia R, Tahar A, Kaki Y A, Bennadja S and Battesti M J 2009 Physicochemical characteristics and pollen spectrum of some north-east Algerian honeys. African Journal of Food, Agriculture, Nutrition and Development, 9, 1276–1293. https://doi.org/10.4314/ajfand.v9i5.45101

Chittka L, Thomson J D and Waser N M 1999 Flower constancy, insect psychology and plant evolution. Naturwissenchaften, 86(8), 361-377. DOI: 10.1007/s001140050636

Cuthbertson A G S and Brown M A 2006 Vital pollinators: Honey bees in apple orchards. Biologist. 53(2), 78–81.

Dobignard A and Chatelain C 2010-2013 Index synonymique de la flore d'Afrique du Nord, 1-4. Genève.

Dongock D N, Tchoumboue J, Ricciardelli D'Albore G, Youmbi, E and Pinta YJ 2007 Spectrum of melliferous plants used by *Apis mellifera adansonii* in the Sudano-Guinean western highlands of Cameroon. Grana. 46(2), 123–128. https://doi.org/10.1080/00173130701318459

Draiaia R, Rezki A R and Chefrour E 2014 Quality of some Algerian honey: study of botanical and some physicochemical parameters. Middle East Journal of Scientific Research, 22(9), 1363–1371. DOI: 10.1016/j.foodcont.2005.08.007

Galloni M and Cristofolini G 2003 Floral rewards and pollination in Cytiseae (Fabaceae). Plant Systematics and Evolution, 238(1), 127–137. DOI: 10.1007/s00606-002-0270-5Floral

Ghorab A, Rodríguez-Flores M S, Nakib R, Escuredo O, Haderbache L, Bekdouche F and Seijo M C 2021 Sensorial, Melissopalynological and Physico-Chemical Characteristics of Honey from Babors Kabylia's Region (Algeria). Foods, 10(2), 225. https://doi.org/10.3390/foods10020225

Grimau L, Gómez M, Figueroa R, Pizarro R, Núñez G, Montenegro G 2014 The importance of weeds as melliferous flora in central Chile. Ciencia e Investigación Agraria. 41(3), 21–22. DOI:10.4067/s0718- 16202014000300011

Guarino R, Vrahnakis M, Rojo M, Giuga L and Pasta S 2020 Grasslands and shrublands of the Mediterranean region. In: Goldstein M, Della Sala D (eds) Encyclopedia of the World's Biomes, vol 2. Oxford Academic Press, Elsevier, 638–655. http://dx.doi.org/10.1016/B978-0-12-409548-9.12119-0

Haderbache L, Bousdira M and Mohammedi A 2013 *Ziziphus lotus* and *Euphorbia bupleuroides* Algerian honeys. World Applied Sciences Journal, 24(11), 1536–1543. DOI: 10.5829/idosi.wasj.2013.24.11.7525

Hamel T 2013 Contribution à l'étude de l'endémisme chez les végétaux vasculaires dans la péninsule de l'Edough (Nord-Est algérien). Thèse de Doctorat en Biologie végétale. Université Badji Mokhtar Annaba, Algérie, 338p.

Hamel T, Bellili A M, Meddad-Hamza A and Boulemtafes A 2019 Nouvelle contribution à l'étude de la flore mellifère et caractérisation pollinique de miels de la Numidie (Nord-Est algérien). Livestock Research for Rural Development, 31, 1–24.

Hamel, T and Boulemtafes A 2017 Plants foraged by bees in the Edough peninsula (Northeast Algeria). Livestock Research for Rural Development, 29, 1–13.

Hicks DM, Ouvrard P, Baldock KC, Baude M, Goddard MA, Kunin WE, Mitschunas N, Memmott J, Morse H, Nikolitsi M, Osgathorpe L M, Potts S G, Robertson K M, Scott A V, Sinclair F, Westbury D B, Stone G N 2016 Food for Pollinators: Quantifying the Nectar and Pollen Resources of Urban Flower Meadows. PLos ONE. 11(6), e0158117. https://doi.org/10.1371/journal.pone.0158117

Homrani M, Escuredo O, Rodríguez-Flores MS, Fatiha D, Mohammed B, Homrani A and Seijo M C 2020 Botanical Origin, Pollen Profile, and Physicochemical Properties of Algerian Honey from Different Bioclimatic Areas. Foods. 9(7), 938. https://doi.org/10.3390/foods9070938.

Hussein MH 2000 A review of beekeeping in Arab countries. Bee World, 81, 56–71. https://doi.org/10.1080/0005772X.2000.11099473

Koçyigit M 2014 The melliferous plants of Apiaceae from Istanbul and their conservation importance. Journal of Faculty of Pharmacy of Istanbul University. 44(2), 181–191.

Laallam H, Boughediri L and Bissati S 2011 Inventaire des Plantes Mellifères du Sud Ouest Algérien. Synthèse: Revue Des Sciences et de La Technologie. 23, 81–89.

Lobreau-Callen D, Darchen R and Le Thomas A 1986 Apport de la palynologie à la connaissance des relations abeilles/plantes en savanes arborées du Togo et du Benin. Apidologie. 17(4), 279–306. https://doi.org/10.1051/apido:19860401

Louveaux J, Maurizio A and Vorwohl, G 1978 Methods of Melissopalynology. Bee World, 59, 139–157.

Mahouachi M 2008 Etude de faisabilité de la mise en place de signes distinctifs de la qualité et/ou d'origine pour le miel tunisien. Ministère de l'agriculture et des ressources hydrauliques Tunisie, 178p.

Makhloufi C, Kerkvliet J and Schweitzer P 2015 Characterization of some monofloral Algerian honeys by pollen analysis. Grana, 54(2), 156–166. https://doi.org/10.1080/00173134.2014.999116.

Marazzi B, González A M, Delgado-Salinas A, Luckow M A, Ringelberg JJ and Hughes CE 2019 Extrafloral nectaries in Leguminosae: Phylogenetic distribution, morphological diversity and evolution. Australian Systematic Botany, 32(6), 409–458. https://doi.org/10.1071/SB19012

Mekious S, Houmani Z and Houmani M 2016 Étude des potentialités mellifères de deux régions du Nord de l'Algérie. Phytothérapie, 1–6. https://doi.org/10.1007/s10298-016-1059-y

Nair S, Meddah, B and Aoues A 2013 Melissopalynological Characterization of North Algerian Honeys. Foods. 2(1), 83–89. https://doi.org/10.3390/foods2010083.

Oddo LPP, Piana L, Bogdanov S, Bentabol A, Gotsiou P, Kerkvliet J, Martin P, Morlot M, Valbuena A O, Ruoff K and Von Der Ohe K 2004 Botanical species giving unifloral honey in Europe. Apidologi, 35, S82–S93. https://doi.org/10.1051/apido:2004045

Quézel P and Santa S 1962-1963 Nouvelle flore de l'Algérie et des régions désertiques méridionales. Tome I et Tome II. CNRS, Paris.

Silici S and Gökceoglu M 2007 Pollen analysis of honeys from Mediterranean region of Anatolia. Grana, 46(1), 57–64. https://doi.org/10.1080/00173130601138783

Valdés B, Díez MJ and Fernández I 1987 Atlas polínico de Andalucía Occidental. Instituto de Desarrollo Regional. Universidad de Sevilla. Excma. Diputación de Cádiz. Sevilla. Spain.

Véla E and Benhouhou S 2007 Évaluation d'un nouveau point chaud de biodiversité végétale dans le Bassin méditerranéen (Afrique du Nord). Comptes rendus biologies, 330(8), 589–605. https://doi.org/10.1016/j.crvi.2007.04.006

Yang Y, Battesti M J, Paolini J, Muselli A, Tomi P and Costa J 2012 Melissopalynological origin determination and volatile composition analysis of Corsican "Erica arborea spring maquis" honeys. Food chemistry, 134(1), 37–47. https://doi.org/10.1016/j.foodchem.2012.02.026

Yang Y, Battesti M J, Costa J and Paolini J 2014 Characterization of botanical and geographical origin of Corsican "spring" honeys by melissopalynological and volatile analysis. Foods, 3(1), 128–148. https://doi.org/10.3390/foods3010128

Zerrouk S, Bougheridi L, Seijo M C, Fallico B, Arena E and Ballistreri G 2013 Pollen spectrum and physicochemical attributes of sulla (*Hedysarum coronarium*) honeys of Médéa region (Algeria). Albanian Journal of Agricultural Sciences, 12(3), 511–517.

Zerrouk S, Seijo M C, Boughediri L and Rodríguez-Flores M S 2014 Palynological characterisation of Algerian honeys according to their geographical and botanical origin. Grana, 53(2), 147–158. https://doi.org/10.1080/00173134.2014.897751.

Zerrouk S, Seijo M C, Escuredo O and Rodríguez-Flores M S 2018 Characterization of *Ziziphus lotus* (jujube) honey produced in Algeria. Journal of Apicultural Research, 57(1), 166–174. https://doi.org/10.1080/00218839.2017.1399663

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