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# Diversity and abundance of wild bees (Hymenoptera: Apoïdea) foraging the flowers of *Hedysarum flexuosum*: Insight through three successive follow-up seasons in Tizi-Ouzou (Algeria)

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**Abstract:**
Monitoring of wild bees foraging on *H. flexuosum* is carried out in Tizi-Ouzou region (northern Algeria), over three consecutive seasons (2017, 2018 and 2019). The inventory reveals the presence of a good diversity of bee species, with 30 wild bee species divided into four families, including 15 species of Apidae, 12 Megachilidae, two Andrenidae and one Halictidae. The two most dominant species during the three years of study belong to the genus *Eucera* namely *Eucera numida* and *Eucera punctatissima* which are long-tongue bees. Shannon-Weaver's diversity index is high in 2019, intermediate in 2017, and relatively low in 2018 with 4.1; 3.5 and 2.5 bits respectively.

**Keywords:** wild bee, *H. flexuosum,* diversity of bees, Tizi-Ouzou, Algeria.

## INTRODUCTION

Wild bees are very diverse and better distributed in the world. This insect group is present on all continents and occupies different environments and climates. The greatest specific richness of wild bees is recorded in the Mediterranean region especially North Africa (Pouvreau, 1983; Vaissiere, 2002; Michener, 2007). In Algeria, there is very few data are available on the existence and distribution of these Apoids if we except the few works carried out by Louadi and Doumandji, (1998); Louadi and *al*. (2008); Aouar(2009); Bendifallah and *al*., (2010, 2012 and 2015), Korichi and *al.* (2019), in different parts of the country and which revealed the existence of a great diversity of wild bee species clustered into 6 families (Apidae, Megachilidae, Halictidae, Andrenidae and Colletidae). Bees are insects that allow pollination of a large number of plant species including those of the genus *Hedysarum* (Sulla), which are widespread in North Africa and native to the Mediterranean region but with being unfortunately endangered (Ben Fadhel and *al.*, 2006). This is the case of *H. flexuosum* which persists only in some regions north of Algeria as isolated populations especially in Tizi-Ouzou (north central Algeria). This plant has almost disappeared in the North under the influence of anthropogenic pressures, either by

overgrazing or by harvesting at the vegetative stage for livestock feeding (Boussaïd and *al*., 2004; Ben Fadhel and *al*., 2006).

The choice of *H. flexuosum* in this study is based on the fact that this plant is highly appreciated by bees as an important source of nectar and pollen. The present work on the inventory of wild bees foraging *H. flexuosum* flowers is the first one to our knowledge. Indeed, data on this plant and its pollinating insects are lacking. Most of research on insect species visiting the Sulla is carried out on a very close plant, *H. coronarium*, given its abundance in the Mediterranean region. Therefore, we find it interesting to investigate the relationship of the threatened *H. flexuosum* with its pollinators by determining diversity and abundance of its wild foraging bee species.

## MATERIAL AND METHOD

The study site is located in Tizi-Ouzou region (36°41'48.01 N, 4°03'30.64 E) which is a part of northern Algeria. The region is characterized by a Mediterranean climate with a mild and rainy winter and a relatively warm summer. The bees are caught while foraging Sulla (*H. flexuosum*), during the flowering period extending between the end of April and May and for three successive years (i.e. 2017, 2018 and 2019). Bee visitors to flowers are sampled weekly during sunny days between 9:00 am and 1:00 pm using a butterfly net. Bees are collected in plastic tubes, containing cotton soaked with ether to suffocate them and kill them quickly without causing them to suffer and without damaging them. Tubes are labeled with location, date and time of sampling.

The collected bees are well spread, dried and stored in entomological boxes at the laboratory for identification. Each specimen is labeled separately with indication of the time and date of sampling. Wild bees are identified using several keys of determination ( Patiny and Terzo, 2010 ; Scheuchl, 2000 and Pauly, 2015a and 2015b), and based on reference material including the collections of this group of insects made by Professor Rasmont and Doctor Terzo from the Laboratory of Zoology (University of Mons, Belgium).

### Methods of data analysis

The diversity index used is Shannon-Weaver H'. It is expressed by the following formula: $H' = -\Sigma\ pi \log2\ pi$, with $pi = ni / N$, pi: the frequency of a given category of individuals relatively to the total number of individuals of all species, ni : the total number of species and N: the total number of individuals of all species (Ramade, 2009).

Equitability is the ratio of observed diversity to maximum diversity. It is expressed by the following formula: $E = H / H'max$ (Barbault, 1981). According to Ramade (2009) equitability (E) is the ratio between observed diversity (H) and maximum theoretical diversity (H max.): $E= H/H\ max$.

## RESULTS

A total of 156 individuals belonging to 30 wild bee species were observed on *H. flexuosum* flowers during the three years of study. These species belong to 15 genera and 4 families (Tab. 01). The Apidae family is the most abundant and diversified in the inventory, representing 71.8% of the total population, with 06 genera and 15 species, followed by the Megachilidae family (21.8% of the total); with 06 genera and 12 species; the Andrenidae (5.8%) with 02 genera and 02 species and the Halictidae family represented by the lowest percentage (0.6%), with 01 genera and one species.

The number of individuals recorded per year is similar in 2017 and 2018 with 55 and 56 individuals respectively; but was lower in 2019 with only 45 specimens. On the other hand, the number of species varies from year to year. Specific diversity is most pronounced in 2017 and 2019 with respectively 19 and 17 species, compared to only 10 species recorded in 2018 (Figure 1).

The Apidea family is the most dominant during the three years of study. It represents more than 50% of the bees visiting the Sulla flowers each year. It peaks of abundance (i.e. 89.3 % of the total number

of bees caught) was observed in 2018 (Fig. 03). The *Eucera* genus is also the most represented with 8 species with the greatest diversity in 2019 (Table 1).

**Table 1: Abundance and frequency of bee visits on *H. flexuosum* flowers during three consecutive years (2017, 2018 and 2019)**

| Families | Genus | Species | 2017 | 2018 | 2019 | ni |
|---|---|---|---|---|---|---|
| **Apidae** | *Eucera* | *Eucera numida* | 10 | 20 | 2 | 32 |
| | | *Eucera punctatissima* | 16 | 15 | 8 | 39 |
| | | *Eucera collaris* | 3 | 7 | 3 | 13 |
| | | *Eucera spatulata* | 0 | 1 | 1 | 2 |
| | | *Eucera pollinosa* | 0 | 0 | 1 | 1 |
| | | *Eucera nigrescens* | 0 | 0 | 1 | 1 |
| | | *Eucera interrupta* | 0 | 0 | 1 | 1 |
| | | *Eucera elongatula* | 0 | 0 | 2 | 2 |
| | *Nomada* | *Nomada nobilis* | 0 | 0 | 2 | 2 |
| | | *Nomada basalis* | 0 | 0 | 1 | 1 |
| | *Ceratina* | *Ceratina cucurbitina* | 3 | 5 | 3 | 11 |
| | *Bombus* | *Bombus terrestris* | 2 | 0 | 0 | 2 |
| | *Anthophora* | *Anthophora quadricolor* | 2 | 0 | 0 | 2 |
| | | *Anthophora plumipes* | 1 | 1 | 0 | 2 |
| | *Tetralonia* | *Tetralonia nigriceps* | 0 | 1 | 0 | 1 |
| **Megachilidae** | *Osmia* | *Osmia heteracantha* | 1 | 0 | 0 | 1 |
| | | *Osmia caerulescens* | 2 | 0 | 3 | 5 |
| | | *Osmia versicolor* | 0 | 0 | 1 | 1 |
| | | *Osmia sp.* | 2 | 0 | 0 | 2 |
| | *Hoplitis* | *Hoplitis adunca* | 3 | 0 | 6 | 9 |
| | | *Hoplitis insularis* | 1 | 0 | 0 | 1 |
| | *Anthidium* | *Anthidium manicatum* | 1 | 1 | 0 | 2 |
| | *Chalicodoma* | *Chalicodoma ericetorum* | 2 | 0 | 5 | 7 |
| | | *Chalicodoma sp.* | 0 | 3 | 0 | 3 |
| | *Chelostoma* | *Chelostoma sp.* | 1 | 0 | 0 | 1 |
| | *Heriades* | *Heriades sp1* | 0 | 0 | 1 | 1 |
| | | *Heriades sp2* | 1 | 0 | 0 | 1 |
| **Andrenidae** | *Andrena* | *Andrena similis* | 2 | 2 | 4 | 8 |
| | *Panurgus* | *Panurgus pici* | 1 | 0 | 0 | 1 |
| **Halictidae** | *Halictus* | *Halictus gemmeus* | 1 | 0 | 0 | 1 |
| **Total** | 15 | 30 | 55 | 56 | 45 | 156 |

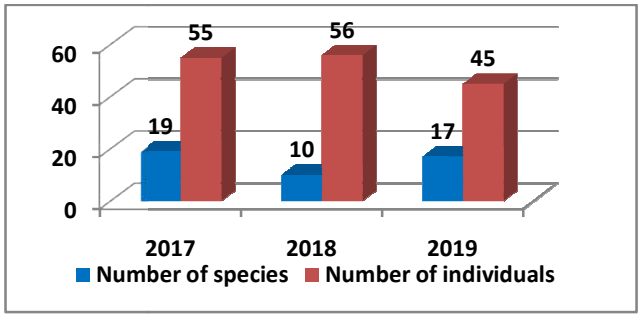


**Figure 1: Distribution of the number of bee individuals and bee species visiting *H. flexuosum* flowers during three consecutive years.**

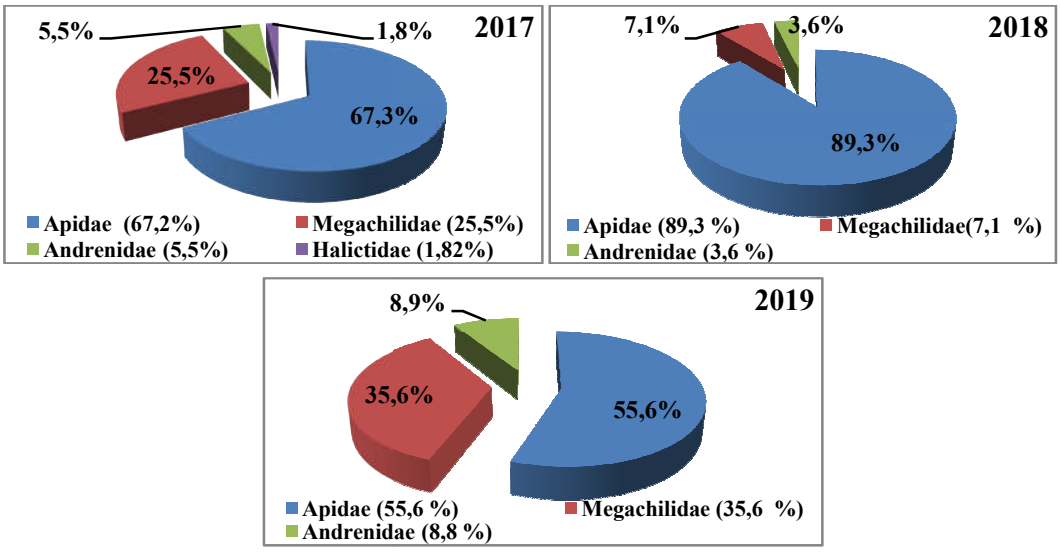


**Figure 2: Distribution of percentage of bee families by year.**

*E. numida* and *E. punctatissima* are the two most dominant species of all the bees caught (Table 1); these two species are also very abundant in 2017 and 2018, but less present in 2019.

The highest Shannon Weaver Diversity Index value (i.e.4.1 bits) was recorded in 2019 and the lowest value (i.e.2.5 bits) was recorded in 2018. The equitability of bees in 2018 and 2019 tends towards 1. This means that there is a balance of distribution of the population under consideration (Figure 3).

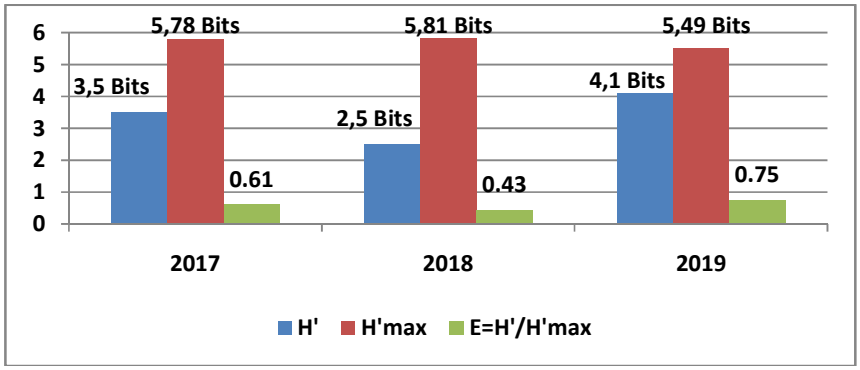


**Figure 3: Shannon-Weaver values (H'), maximum diversity (H'max) and equitability (E) of the bees recorded on *H. flexuosum* over there consecutive years**

## DISCUSSION AND CONCLUSION

This study shows that *H. flexuosum* flowers attract a wide variety of wild pollinating bee species (30 species). The same results were reported in China by Tepedino and Stackliousc (1987) who listed 36 species of wild bees on *Hedysarum boreale* Nutt., 1818. However, work on *H. coronarium*, by Montero-Castâno and Vila (2016), shows that this plant species is less visited by wild bees with only 09 species recorded during 2-year follow-up period. It is the same for the work carried out in Italy by Ricciardelli D'albore (1993) which observed only 3 species over 4 years of study. Observations of foraging behaviour of wild bees by the daily monitoring method on *H. coronarium* carried out in Italy by Galonie and *al*. (2008) identified 5 species of solitary bees during a single flowering period. For

another species of *Hedysarum*, *H. scoparium* from China, Pan and *al*. (2012) identified 7 species of solitary bees on flowers over 2 years of observation.

In addition, observations on another more studied legume, the bean (*Vicia faba*), reveal the presence of wild bee species. Indeed, Aouar and *al*. (2008) report the presence of 08 visiting species in Tizi-Ouzou region. Benachour and *al*. (2007) identified 07 species of wild bees in Constantine region on the same plant. In addition, in Finland, Varis (1995) reports the presence of 3 species of Bombus on the flowers of *V. faba*.

The present study indicates that bee specific richness differs by study season. Apoid wildlife is more diverse in 2017 with 19 species present. This is probably due to the abundance of Sulla in 2017 compared to the other two years. In 2018, we observed a sharp decline in specific richness with only 10 species present. However, the number of individuals caught each year does not differ significantly. Sulla is found in the study site every year. However, for the period extending from 16 to 21 May and from 26 to 30 May 2018, the study site experienced very severe weather conditions with rain followed by thunderstorms and strong winds (Figures 4 and 5), which caused extensive damage to Sulla patches and the deterioration of more than half of the flowers. A sharp decline in foraging species is observed in 2018 and 2019; despite this a good number of individuals are recorded in 2018. However, in 2019 we noticed a good diversity of species. Shannon-Weaver's diversity is the highest in 2019, intermediate in 2017 and the lowest in 2018. While it is low in 2018 with only 2.5 bits. This can be explained by the low flower abundance in 2018 at the study site due to weather conditions, and the bees having a wide variety of choices for feeding on other flowers present at the site.

It is known that long-tongue bees are the most commonly encountered on Sulla flowers (Sonet and Jacob- Remarcle, 1987; Satta and *al*. 2000; Montero-Castaño *et al.,* 2014, 2015 and 2016). Indeed, in the present study, the Apidae family is the most represented with 15 species and 06 genera identified. Sonet and Jacob- Remarcle (1987), confirm that wild bees, especially the genus *Eucera* is best adapted to the floral morphology of the Sulla. The monitoring of bees foraging *H. flexuosum* flowers allowed highlighting two abundant species: *E. punctatissima* (39 individuals) and *E. numida* (32 individuals). This is concordant with Satta and *al*. (2000) who reported the abundance of *E. numida* on *H. coronarium* flowers. Similarly, Sonet and Jacob Remarcle (1987) reported *E. numida* as the most abundant wild species on *H. coronarium* flowers. Conversely, Tepedino and Stackliousc (1987) reported *Tetralonia frater* as the most abundant species on *Hedysarum boreale* flowers of. According to Pan and *al*. (2012), *Amegilla sp*. is the most common wild bee on *H. scoparium*. For bee species visiting *V. faba*, Aouar and *al*. (2008) noticed that *E. pulveracea* is the most present species. Varis (1995), on the other hand, states that the genus *Bombus* and especially *B. subterraneus* is very abundant on *V. faba* flowers in Finland.

The Megachilidae are also long-tongue bees and represented the second most foraging family in the present study with a considerable diversity, i.e. 12 species distributed over 6 genera. Our observations indicate that visits of the Megachilidae are not focused on *Hedysarum* flowers of. Despite the great diversity of species, their abundance is relatively low.

Short tongue bees are poorly represented with two species of the Andrenidae and only one species of the Halictidae. *A. similis* is present during the three years of study. As a result of its short tongue, it feeds on the flowers at the moment of their optimal opening; the stamens are visible and exited between the petals which allow this bee to harvest pollen easily.

Monitoring of wild bees foraging *H. flexuosum* shows us that the flowers of this plant attract a great diversity of species. Due to its very high allogamous character, the Sulla relies on the presence of pollinators, especially bees, to reproduce (Cheriki, 1984). Reciprocally bees find Sulla flowers all the pollen and nectar necessary for their survival and their offspring development.

The preservation of spontaneous plants is important to guarantee the sustainability of the Apoids and especially wild bee species. Most of wild bees have a solitary life style contrary to social bees. This make the former category difficult to localize and follow-up in order to settle targeted conservation measures it is therefore more interesting to conserve the natural environment around nests of these

solitary bees. We also suggest conducting deeper studies in order to determine the food preferences of wild bees and to better know the plant-pollinator complex where bees play a leading role in maintaining this association and the ecosystem.

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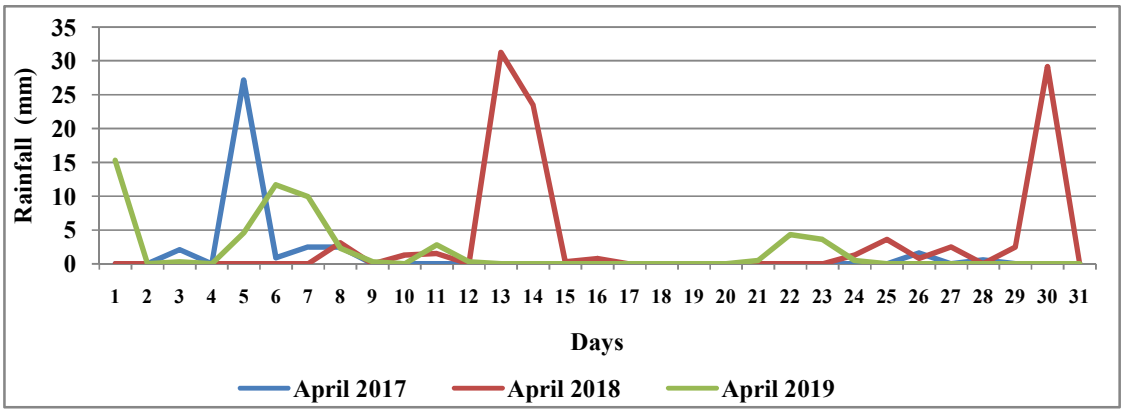


**Figure 4**: **Rainfall variations in Tizi-Ouzou area during April of three consecutive years (N.M.O.T.O, 2019).**

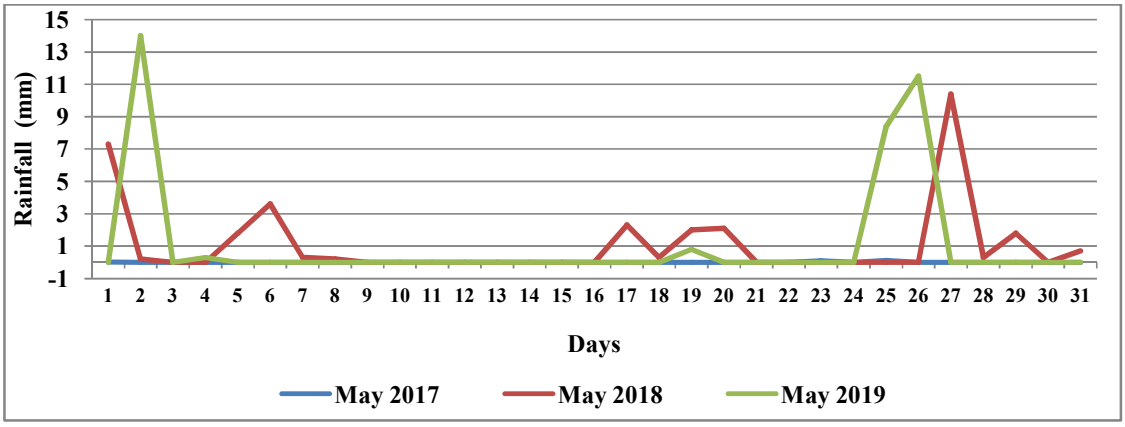


**Figure 5: Rainfall variations in Tizi-Ouzou area during May of three consecutive years (N.M.O.T.O, 2019).**

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