Diversity of the Insect Visitors on *Calluna vulgaris* (Ericaceae) in Southern France Heathlands

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ABSTRACT. As part of an ongoing research project on the pollination networks in European heathlands, the objective of this study was to assess the insect visitor guild on *Calluna vulgaris* (L.) Hull (Ericaceae). We focused the study on a region renowned for its largely well-preserved heathlands, the Cévennes National Park, Southern France. In 2013, flower visitors were observed over 3 d per site, in four heathland sites at mont Lozère. Honeybees (*Apis mellifera* L.) were the main visitors (62–88% of total visitors). Besides honeybees, a high diversity of visitors was detected with 57 different species identified (42 Diptera and 15 Hymenoptera). Hoverflies (*Syrphidae*, *Diptera*) visitors were abundant and diverse, especially individuals belonging to the genera *Eristalis* and *Episyrphus*. The reported diversity of visitors was probably due to the preservation of large heathland areas at mont Lozère and to the generalist pollination system of *C. vulgaris*.

RESUME. Cette étude fait partie d’un projet de recherche en cours sur les réseaux de pollinisation dans les landes européennes. Son objectif est d’évaluer la guilde des insectes visiteurs de *Calluna vulgaris* (L.) Hull (Ericaceae). Cette étude se déroule dans une région réputée pour ses landes globalement bien préservées: le Parc national des Cévennes, situé dans le sud de la France. En 2013, les insectes visiteurs ont été observés durant trois jours par site, dans quatre sites au mont Lozère. Les abeilles domestiques (*A. mellifera* L.) sont les visiteurs principaux (62–88% du nombre total de visiteurs). Outre les abeilles domestiques, une diversité importante de visiteurs est constatée: 57 espèces ont été identifiées (42 appartenant à l’ordre des Diptères et 15 à l’ordre des Hyménoptères). Les syrphes (*Syrphidae*, *Diptera*) sont abondants et diversifiés, en particulier les genres *Eristalis* et *Episyrphus*. La diversité de visiteurs observée peut certainement s’expliquer par la préservation de grandes étendues de landes au mont Lozère et par le caractère généraliste de la pollinisation de la callune.

Key Words: pollination network, Cévennes National Park, heather, Syrphidae, Apidae

Pollinators are declining (Patiny et al. 2009, Potts et al. 2010, Brown 2011). The loss of insect species and subsequent homogenization could significantly alter the stability of pollination networks and further threaten the maintenance of plant communities and global diversity (Memmott et al. 2004, Hadley and Betts 2012). The main causes of the current loss of pollinators are related to anthropogenic activities (Brown and Paxton 2009). Among these causes, habitat loss, fragmentation, and disturbance modify the landscape matrix (Goulson et al. 2008, Kleijn and Raemakers 2008, Winfree et al. 2009). Throughout Europe, habitat loss and fragmentation especially impact open habitats like dry grasslands, fallow lands, or heathlands (Steffan-Dewenter and Tscharntke 1999, Rasmont et al. 2005). The flowering species in these biotopes are crucial for insect pollinators, which depend on floral resources for feeding (Mayer et al. 2012, Somme et al. 2014). Floral resources are composed of nectar and/or pollen. Pollen represents the source of proteins, amino acids, lipids (mainly sterols) as well as of some vitamins. Nectar constitutes mainly the resource in sugars (Goulson 2010).

In Europe, ancestral extensive agricultural practices have created original open habitats, hosting a high biodiversity (Diemont et al. 2013). Heathlands, mainly originating from sheep and cattle grazing, consist of oligotrophic biotopes and are dominated by ericaceous dwarf shrubs (Gimmingham 1972, Webb 1998). These heathlands have largely been destroyed or fragmented over the last two centuries (Gimmingham 1972, Aerts and Heil 1993, Webb 1998, Piessens and Hermy 2006) and were converted into agricultural or afforested areas (e.g., pine plantations in the Cévennes region, Parc National des Cévennes [PNC] 2007). In Europe, a densely populated continent, nature conservation priorities focus on these “historical” biotopes. The Natura2000 network considers several open biotopes of high priority (calcareae grasslands, saline marshes, and wet and dry heathlands, Diemont et al. 2013). Among these open habitats, heathlands remain poorly studied (Mahy et al. 1998, Mayer et al. 2012, Diemont et al. 2013). Therefore, little is known over the current diversity and abundance of the local wild insect pollinators. Yet, heathlands host several specialist pollinators, particularly sensitive to decline, which are dependent on the floral resources of ericaceous species (Goulson et al. 2005, Mayer et al. 2012). For instance, the solitary bee *Andrena lapponica* Zetterstedt collects pollen mainly from *Vaccinium* species. Heathlands also constitute the exclusive habitat for *Bombus monticola* Smith and *Bombus jonellus* Kirby, the latter being a decreasing bumblebee species (Rasmont et al. 1993). Little is known about other insect pollinators besides the fact that syrphid flies are increasingly recognized as efficient pollinators of numerous plant species (Goulson and Wright 1998, Jacquemart et al. 2007, Sarthou 2011, Inouye et al. 2015). Pollination efficiency of Syrphidae varies among species, and large species (like *Sericomya* and *Eristalis*) are considered as valuable pollinators (Mahy et al. 1998, Jacquemart et al. 2007).

*Calluna vulgaris* (L.) Hull (Ericaceae), the heather, usually constitutes the dominant species in dry heathlands (Diemont et al. 2013). The species is a small, evergreen shrub (50–100 cm in height). The small flowers, which measure 5–8 mm in length, are tetramerae and grouped in racemes. The flowering period extends from July to September according to the location of the heathlands (Gimmingham 1960). The...
species is pollinated by insects, although wind is also reported to be a pollinating agent (Mahy et al. 1998). The species is crucial for insects at the end of the season, since it represents large stands of flowers and offers large quantities of pollen and nectar (Mahy and Jacquemart 1998, Vanderplanck et al. 2014). Compared with several Ericaceae species, which present poridical anthers and force visitors to vibrate the anthers to release pollen (e.g., buzz-pollination, Jacquemart 2003), the anthers of C. vulgaris present longitudinal splits that allow an easy access to pollen to a large diversity of insects. Only a few species are able to perform buzzing, in particular bumblebees (Buchmann et al. 1983). Since C. vulgaris is an emblematic plant species in heathlands at mont Lozère and little is known about the current diversity and abundance of wild pollinators, the main objective of this study was to investigate the visitor guild of C. vulgaris.

This study is part of an ongoing larger research project whose goal is to compare pollinator guilds and their abundances in different European heathlands to establish guidelines for heathland restoration and management. In mont Lozère, heathlands remain large and in a relatively good conservation status. We therefore hypothesize that these heathlands will maintain a higher diversity and abundance of insect visitors relative to smaller size remnants. (Diemont et al. 2013).

Materials and Methods

The study took place at mont Lozère (Languedoc-Roussillon, France). This granite massif is located along the southeastern margin of Massif Central and is included in the central part of the Cévennes National Park. The mont Lozère presents a steep relief (highest peak at 1,699 m) and mountainous climatic conditions. Biotopes of this area are influenced by the Atlantic Ocean in the Western part and by the Mediterranean Sea in its Eastern part. Such climatic influences generate diversified biotopes, which shelter unique flora and fauna, including several endemic species (PNC 2007). Because of a local rapid human demographic growth in the middle of the 19th century, land-use modifications induced important changes to the vegetation cover, which led to huge soil erosion and catastrophic floods in the valleys. To counteract soil erosion, ambitious tree plantation programs (particularly with Pinus sylvestris) took place at mont Lozère at the end of the 19th century. The abandonment of agro-pastoral practices in the 20th century strengthened scrub encroachment dynamics, further reducing heathland cover (Lhuillier 2000). Nowadays, Calluna heathlands still cover about 1,550 ha at mont Lozère, due to the management of these biotopes through extensive cattle and sheep grazing linked to transhumance (seasonal move to summer pastures, Parc National des Cévennes [PNC] 2012). These heathlands belong to the Genisto pilosae-Vaccinion uliginosii-B.1926 alliance (Boissier 2002).

Observations were conducted in 2013 in four sites (Table 1) ranging between 1,290 and 1,530 m a.s.l. Flower visitors were recorded during peak of flowering of C. vulgaris over 3 consecutive days per site. Observations were conducted for 20 min every hour between 8:30 a.m. and 5:30 p.m. between August 22 and September 3. All insect individuals foraging on C. vulgaris were collected with an insect net on a 10 m² plot of continuous Calluna shrub cover. Because of apiary activities in the region, honeybees largely dominated the insect guild. At each site, two people collected the insect visitors, including honeybees, on the first day of observation. On days 2 and 3, one person collected the insect visitors, excluding honeybees. After the 20-min period, the insects were identified and released. Several individuals per insect morphotype were killed and caught for further identification (Table 3).

Flowering plant surveys following the Braun-Blanquet method were made on 100 m² plot each site in the vicinity of the plot of insect visitor surveys (Table 2). The flowering plant diversity per site represented the total number of entomophilous species in flower at the time of the survey. A higher number of flowering species was recorded at Villeneuve site compared with the other three sites (15 vs. 7–11). The high number was due to the proximity of meadows, whereas the other sites were situated in a landscape matrix including only coniferous forests and heathlands within a radius of 500 m.

For statistical analyses, we grouped insect visitors in four groups: two groups for Hymenoptera, honeybees (Apis mellifera) and other Hymenoptera; and two groups for Diptera, hoverflies (Syrpidae) and other Diptera. Pearson correlation tests were used to determine whether the abundances of visitor groups and flowering plant diversity were statistically correlated.

Results

In total, 57 species of insect visitors were observed, including 42 Diptera and 15 Hymenoptera species (Table 3). Honeybees were the main visitors representing 76% (range 62–88%) of the observed visitors over all sites (Fig. 1A). Besides honeybees, 462 insect individuals were collected on C. vulgaris. Most of them belonged to the Diptera order (84%), which mainly consisted of Syrfidae and more specifically to the Eristalis genus. Individuals from this genus represented more than 40% of Syrfidae. Individuals from the Hymenoptera order only represented 16% of the visitors, among which 7% were bumblebees (Fig. 1B).

The abundance of Hymenoptera visitors ("other Hymenoptera" group, excluding honeybees) was positively correlated to flowering plant diversity, namely the number of plant species flowering around the observation plots (Pearson correlation, $r = 0.973$, $P = 0.027$, Table 2). Villeneuve and Finiels 15 and 11 flowering species, respectively, presented the highest abundance of “other Hymenoptera” visitors (Fig. 1B).

Table 1. Characteristics of the four sites of C. vulgaris at mont Lozère

| Population | Municipality       | Coordinates       | Altitude (m) | Flowering plant diversity | Forest cover (%) | Date of insect surveys       |
|------------|--------------------|-------------------|--------------|---------------------------|-----------------|-------------------------------|
| Barrandon  | Saint-Etienne-du-Valdonnez | 44° 27’17.95” N 3° 36’59.81” E | 1,387        | 10                         | 90              | 1 September 2013               |
|            |                    |                   |              |                           |                 | 2 September 2013               |
|            |                    |                   |              |                           |                 | 3 September 2013               |
|            |                    |                   |              |                           |                 | 22 August 2013                 |
|            |                    |                   |              |                           |                 | 23 August 2013                 |
|            |                    |                   |              |                           |                 | 24 August 2013                 |
|            |                    |                   |              |                           |                 | 25 August 2013                 |
|            |                    |                   |              |                           |                 | 26 August 2013                 |
|            |                    |                   |              |                           |                 | 27 August 2013                 |
|            |                    |                   |              |                           |                 | 29 August 2013                 |
|            |                    |                   |              |                           |                 | 30 August 2013                 |
|            |                    |                   |              |                           |                 | 31 August 2013                 |

Flowering plant diversity refers to the number of entomophilous plant species flowering within a 50-m radius around the insect observation plots. Forest cover refers to the percentage of forest cover in a 1,000 m radius from the centre of the site.
### Table 2. Abundance of flowering plant species in the four study sites at mont Lozère on a 100 m² plot per site

| Family       | Species                                      | Barrandon | Bleymond | Finiels | Villeneuve |
|--------------|----------------------------------------------|-----------|----------|---------|------------|
| Asteraceae   | *Achillea millefolium* L.                    | 1         | 3        | 1       | 1          |
|              | *Hieracium gr. glaucinum*                    |           |          |         |            |
|              | *Hieracium pilosella* L.                     | 1         |          |         |            |
|              | *Serratula tinctoria* L.                     | +         |          | +       |            |
| Campanulaceae| *Campanula rotundifolia* L.                  | 1         |          | 1       | 1          |
|              | *Jasione laveis Lam.*                       | +         |          |         |            |
|              | *Jasione montana* L.                        | +         |          | +       | 1          |
| Caryophyllaceae| *Dianthus sylvaticus* Hoppe ex Willd.     | 4         | 4        | 4       | 3          |
| Dipsacaceae  | *Succisa pratensis* Moench                   |           |          |         |            |
| Ericaceae    | *Calluna vulgaris* Hull.                    | 1         |          |         | 1          |
| Fabaceae     | *Genista pilosa* Hoppe ex Willd.            |           |          |         |            |
|              | *Lotus corniculatus* L.                     |           |          |         |            |
| Lamiaceae    | *Betonica officinalis* L.                   |           |          |         |            |
|              | *Thymus praecox* ssp. polytichus Jalas      |           |          |         | 1          |
| Caryophyllaceae| *Euphrasia* spp.                            | +         |          |         |            |
| Rosaceae     | *Alchemilla saxatilis* Buser                 | +         | 1        | 2       | 1          |
| Rubiaceae    | *Galium verum* L.                           | 1         | 1        | 1       | 1          |
| Scrophulariaceae| *Linaria repens* L.                           | +         |          |         |            |
|              | *Linaria spp.*                              | +         |          |         |            |
| Violaceae    | *Viola canina* L.                           | +         |          | +       | 1          |

Plant species abundance was assessed using Braun-Blanquet scale: +, sparse individuals (<10 individuals); 1, cover < 5%; 2, cover 5–25%; 3, cover 25–50%; 4, cover 50–75%; 5, cover >75%.

### Table 3. Insect individuals collected on *C. vulgaris* in the four study sites

| Order         | Family       | Species                                      | Barrandon | Bleymond | Finiels | Villeneuve |
|---------------|--------------|----------------------------------------------|-----------|----------|---------|------------|
| Hymenoptera   | Andrenidae   | *Andrena flavipes* (Panzer 1799)             | X         |          |         |            |
|               |              | *Andrena* spp.                               |           |          |         |            |
|               | Apidae       | *Bombus lapidarius* (L. 1758)                | X         |          |         |            |
|               |              | *Bombus quadricolor* (L. 1758)               |           |          |         |            |
|               |              | *Bombus soroensis* (F. 1793)                 | X         | X        | X       | X          |
|               |              | *Bombus soroensis* (F. 1793)                 | X         | X        | X       | X          |
|               |              | *Bombus sylvan* (L. 1758)                    | X         | X        | X       | X          |
|               |              | *Xylocopa violacea* (L. 1758)                | X         |          |         |            |
| Colletidae    | *Colletes hederae* (Schmidt and Westrich 1993) | X         |          |         |          |            |
| Halictidae    |              | *Halictus rubicundus* (Christ 1791)          |           |          |         |            |
|               |              | *Lasioglossum* cfr. malachurum (Kirby 1802)  |           |          |         |            |
|               |              | *Lasioglossum* sp.                           |           |          |         |            |
| Ichneumonidinae|              | *Ichneumoninae* sp.                          |           |          |         |            |
| Vespidae      | *Conopidae*  | *Myopa fasciata* (Meigen 1804)               | X         |          |         |            |
|               |              | *Myopa variegata* (Meigen 1804)              | X         |          |         |            |
| Empididae     | *Musca autumnalis* (De Geer 1776)           | X         |          |         |         |            |
| Syrphidae     | *Callicera aurata* (Rossi 1790)             | X         |          |         |         |            |
|               |              | *Chrysotoxum arcuatum* (L. 1758)             | X         |          |         |            |
|               |              | *Chrysotoxum festivum* (L. 1758)             | X         |          |         |            |
| Diptera       | Tachinidae   | *Gymnosoma rotundatum* (L. 1758)             | X         |          |         |            |
|               |              | *Thereva nobilitata* (Wiedemann 1830)        |           |          |         |            |
|               |              | *Syritta pipiens* (L. 1758)                  | X         |          |         |            |
|               |              | *Syritta plumifera* (L. 1758)                | X         |          |         |            |
|               |              | *Syritta nigros* (L. 1758)                   | X         |          |         |            |
|               |              | *Syritta sylvarum* (L. 1758)                 | X         |          |         |            |
|               |              | *Syritta pulchella* (L. 1758)                | X         |          |         |            |
|               |              | *Xanthandrus cornutus* (Harris 1780)         | X         |          |         |            |
|               | Tachinidae   | *Gymnosoma rotundatum* (L. 1758)             | X         |          |         |            |
|               |              | *Therioptilus* (Harris 1780)                 | X         |          |         |            |
|               |              | *Syritta nigros* (L. 1758)                   | X         |          |         |            |

For individual belonging to Ichneumonidinae family, the identification was not possible beyond the subfamily level.
group was calculated as the ratio between the numbers of insects of each group against the total numbers of insect visitors observed during the 3 d. (A) Relative abundance of visitor groups on day 1 for each site including A. mellifera. Other Hymenoptera refers to Hymenoptera species, except Syrphidae, and Other Hymenoptera refers to Hymenoptera species, except A. mellifera.

Discussion

The number of insect species observed on the flowers of C. vulgaris in our study (57 species) confirmed its generalist pollination system and supported results from previous studies from The Netherlands (61 species, Beijerinck 1940) or Belgium (50 species, Mahy et al. 1998, Bacchetta 2014). This generalist system might be explained by the access to floral resources (pollen and nectar). C. vulgaris has an open small sized (<6 mm) corolla allowing easy access to nectar.

Fourteen new insect species belonging to the Syrphidae family were added to a list of 104 species identified by Sarthou et al. (2010) in Lozère. Callicera aurata Rossi, Chrysotoxum festivum L., Didea intermedia Loew, Epistrophe euchroma Kowarz, Eristalis pratorum Meigen, Metasyrphus luniger Meigen, Sacaeva pyrastr L., Sacaeva pyrastri var. unicolor L., Sacaeva selenitica Meigen, Sericomia silentis Harris, Sphaerophoria menthastri L., Syrphus vitripennis Meigen, Volucella pellucens L., and Xanthandrus comus Harris have never been observed before in the department of Lozère. Some of the insect species observed, such as S. pyrastr, Sc. silentis, or Sy. vitripennis, have already been reported to visit C. vulgaris flowers in Belgium (Mahy et al. 1998).

Honeybees dominated the visitor guild. The ubiquitous beekeeping at mont Lozère (Lehbel-Peron 2012) might explain their abundance. Hives are installed mainly in late summer, during the flowering period of the heather. Heather honey is still appreciated in several European countries (Lehbel-Peron 2012). Honeybees might negatively impact wild pollinator populations. We only observed 33 bumblebee individuals, whereas Hymenoptera, especially bumblebees, are considered as the main pollinators of C. vulgaris in Germany (Knuth 1908, Jeunieaux et al. 2014), Belgium (Mahy et al. 1998; Bacchetta 2014), The Netherlands (Beijerinck 1940), the United Kingdom (Willis and Burkill 1895, Gimingham 1960). Bumblebee population dynamics could be affected by emerging infectious diseases transmitted by honeybees (Furst et al. 2014). Honeybees compete with wild pollinators for access to floral resources. Competition effects on native pollinators have been demonstrated in several countries where honeybees were introduced (Australia [Goulson 2003, Paini 2004] and the United States [Thomson 2004]), but few convincing results are available for countries where honeybees are native (Steifan-Dewenter and Tscharntke 2000). The low abundance of bumblebees at mont Lozere may be explained by the colony phenology as the production of workers may be reduced in the fall when new queens emerge (Iseryt and Rasmont 2012). Future investigations on the insect community and particularly on bumblebees, within the mont Lozère area over several years will extent the existing list of pollinators.

Our study further highlighted the influence of flowering plant diversity on the abundance and diversity of visitors (Nicolson 2007, Munidasa and Toquenaga 2010, Jha and Kremen 2012). The abundance of Hymenoptera, except honeybees, was positively linked to the abundance and diversity present in the vicinity of the study sites (e.g., Genista pilosa and Campanula rotundifolia). Bumblebee and solitary bee species usually collect pollen and nectar from several plant species (i.e. polylecticism, Michener 2007). Besides the relative abundance and density of a plant species in the surrounding of the bee nest, the composition of its pollen and nectar might have been reported to influence the foraging behavior of bees since they rely exclusively on these floral resources for larvae feeding (Vanderplanck et al. 2014, Somme et al. 2015, Moquet et al. 2015).

Acknowledgments

We are grateful to A. Lehbel-Peron and M. Milor for site information and C. Robin and C. Mallet for the accommodation of C. D. at Mont Lozère and S. Francoise for field assistance. Many thanks are due to B. Righetti, N. Vereecken, P. Grootaert, and C. Martens for assistance in insect identification, F. Hopkins and P. Lhoir for plant identification. We thank the Cevennes National Park for allowing us to sample plants and insect individuals. We also thank two anonymous reviewers for their constructive comments on the manuscript. This work was supported by Belgian Fund for Scientific Research (FNRS contract 2.4613.12) and the Universite catholique de Louvain (FSR project). This work is part of a project focusing on the availability of floral resources in European heathlands and their impacts on pollinator diversity, abundance, and behavior (L. Moquet, Ph.D. thesis). This study constituted the master thesis of C. Descamps.
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