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To cite this article: Mira Boustani, Wael Yammine, Nabil Nemer, Efat Abou Fakhr Hammad, Denis Michez & Pierre Rasmont (2020): Distribution and flower visitation records of bumblebees in Lebanon (Hymenoptera: Apidae), Annales de la Société entomologique de France (N.S.), DOI: 10.1080/00379271.2020.1749885

To link to this article: https://doi.org/10.1080/00379271.2020.1749885
Distribution and flower visitation records of bumblebees in Lebanon (Hymenoptera: Apidae)

Mira Boustani*, Wael Yammineb, Nabil Nemer, Efat Abou Fakhr Hammad, Denis Michezw & Pierre Rasmont

aLaboratory of Zoology, University of Mons, Place du Parc, 20, 7000, Mons, Belgium; bDepartment of Plant Protection, Faculty of Agricultural & Veterinary Sciences, Lebanese University, Dekwaneh, Beirut, Lebanon; cDepartment of Agriculture and Food Engineering, Holy Spirit University of Kaslik, PO Box 446, Jounieh, Lebanon

(Accepté le 27 mars 2020)

Summary. West Palearctic bumblebees are common wildflowers and crop pollinators that are well studied in their central and northern distribution ranges, but fewer information is available on their southern distribution areas. Lebanon falls on the southern limit of their distribution and no published information is available on the local bumblebees. Our study aims to produce a data baseline of the local bumblebee species. In order to do so we grouped available old records of bumblebees in Lebanon with recent author collections and produced preliminary distribution maps. We listed four species: *Bombus terrestris*, *B. argillaceus*, *B. niveatus vorticosus* and *B. melanurus*. Preliminary distribution shows that *Bombus terrestris* and *B. argillaceus* are widespread and have a large foraging range, whereas *B. niveatus vorticosus* and *B. melanurus* have a restricted distribution to altitudes above 1800 m with a smaller foraging range. The male cephalic labial gland secretions analysis of local *Bombus terrestris* specimens provides preliminary evidence that the local subspecies could be *Bombus terrestris calabricus*. Therefore, we highlight the importance of regulating foreign *Bombus terrestris* subspecies importation for agriculture purposes, as well as monitoring *B. niveatus vorticosus* and *B. melanurus* that are rendered vulnerable by their isolated populations.


Les bourdons du Paléarctique occidental sont des pollinisateurs communs de fleurs sauvages et de cultures, qui sont bien étudiés dans leurs aires de répartition centrale et septentrionale, mais moins d’informations sont disponibles pour leurs aires de distribution méridionales. Le Liban se trouve à la limite sud de leur répartition et aucune information publiée n’est disponible sur les bourdons locaux. Notre étude vise à produire une base de données sur les espèces locales de bourdons. Pour ce faire, nous avons regroupé les anciens signalements disponibles de bourdons au Liban avec les collections récentes des auteurs, et produit des cartes de distribution préliminaires. Nous avons répertorié quatre espèces : *Bombus terrestris*, *B. argillaceus*, *B. niveatus vorticosus* et *B. melanurus*. La distribution préliminaire montre que *Bombus terrestris* et *B. argillaceus* sont répandus et ont une aire de butinage tendue, tandis que *B. niveatus vorticosus* et *B. melanurus* ont une distribution restreinte à des altitudes supérieures à 1800 m, avec une aire de butinage plus petite. L’analyse des sécrétions des glandes labiales céphaliques mâles des spécimens locaux de *Bombus terrestris* fournit une preuve préliminaire que la sous-espèce locale pourrait être *B. terrestris calabricus*. Par conséquent, nous soulignons l’importance de réglementer l’importation de sous-espèces étrangères de *Bombus terrestris* à des fins agricoles, ainsi que de surveiller *B. niveatus vorticosus* et *B. melanurus*, rendus vulnérables par l’isolement de leurs populations.

Keywords: bio diversity; distribution; pollination; faunistics; Palaearctic; Near East

Bumblebees (*Bombus* Latreille, 1802) form a genus of wild bees that includes about 260 species worldwide (Williams 1998; Cameron & Sadd 2020). They are pollinators of many wild plants and cultivated crops (Mánd et al. 2002; Goulson 2010; Ballantyne et al. 2015). Well adapted to colder regions, they are found all over Europe and Asia to the Arctic. They are also present throughout the Americas but are absent from Africa south of the Sahara and from Oceania (Williams 1998; Hines 2008; Rasmont & Iserbyt 2010-2014), except New Zealand and Tasmania where they have been imported for pollination (Goulson & Hanley 2004). The West Palearctic distribution and status of bumblebees are relatively well documented (Rasmont et al. 2015), but less information is available on species found in the south of this region, including Lebanon. The topography of this country presents several mountainous areas that are potentially favorable to bumblebees (Özbek 2002; Rasmont & Iserbyt 2010-2014; Saini et al. 2012). However, the Lebanese wild bee fauna remains poorly documented. The main references are from Mavromoustakis (1955, 1956, 1962) that produced an inventory of wild bees belonging mainly to the tribes Anthidiini and Osminii based on his own collection trips, as well as describing several new species. His findings were included in the review compiled by Grace (2010). Aside from these

*Corresponding author. Email: boustany.mira@gmail.com
records, to our knowledge there have been no documented findings. On the other hand, records from neighboring countries report 45 species from Turkey (Rasmont et al. 2009), two from Syria (Solaiman-Khaled et al. 2012) and Israel (Rasmont & Iserbyt 2010-2014).

In order to fill this gap of information on the presence and diversity of Lebanese bumblebees, our objectives for this paper are to present our observations from several habitats across Lebanon, and secondly to assemble unpublished records and museum collection specimens in order to produce a biogeographic data baseline.

Materials and methods

Study area

Our collections were carried out in the governorates of North Lebanon, Mount Lebanon and Beqaa. Following the vegetation levels classification of Abi-Saleh & Sati (1988), the collection areas fall into the Eumediterranean (500–1000 m), Supramediterranean (1000–1500 m), Montane Mediterranean (1500–2000 m) and Oromediterranean (>2000 m) on the western slopes of Mount Lebanon (Typical Mediterranean); and into the Mediterranean (1000–1500 m), Supramediterranean (1400–1800 m), Montane Mediterranean (1800–2400 m) and Oromediterranean (>2400 m) on the Eastern slopes (Presteppe Mediterranean). It has to be noted when validating old data that the Lebanese border has undergone changes from Ottoman Empire, the French mandate and independence (Barnett et al. 2019). In this paper, we only consider the present Lebanese borders (from 1943).

New specimen collection protocols

Collections were carried out individually by M. Boustani, W. Yammine and P. Rasmont between April 2016 and September 2017 in the following regions separately: Ammiq (973 m), Baskinta (1430 m), Beit Chabab (740 m), Dahr El Qabib (2500 m) and Qornael (1234 m). Collections were also carried out on a transect between Tannourine El Tahta (900 m) and Arz Tannourine (1800 m), and between Arz Bcharre (1800 m) and Qornet El Sawda (3000 m).

All collections were made using hand nets. Bee specimens were killed using ethyl acetate or by freezing, then pinned and identified to species level, using reference specimens from the University of Mons collection. Flowers visited by bumblebees were sampled by collecting specimens for herbarium, they were then identified to species level using Mouterde (1966, 1970, 1984).

Databasing and mapping

Bombus specimens from entomological student collections of the American University of Beirut (AUB) and the Holy Spirit University of Kaslik (USEK) collections were examined, identified, and integrated into our database in addition to the new specimens collected. We also integrated the available original data from Lebanon included in the Banque de Données Fauniques de Gembloux et Mons.

Specimens without labels were eliminated from the counts. Specimens labeled only with country name were included in the counts but are not displayed on the map.

All data were digitized using Data Fauna Flora 5.1.2 (Barbier et al. 2000) and mapped with Quantum GIS 2.18.27.

Subspecies identification of Bombus terrestris samples

The diagnostic character of cephalic labial gland secretions (CLGS) is often used as a tool to delimitate bumblebee species (e.g. Lecocq et al. 2015b; Martinet et al. 2018) and has also been used to differentiate subspecies in Bombus terrestris (Lecocq et al. 2016). We cross-checked the morphological subspecies identifications of B. terrestris with a quantitative GC-FID analysis of CLGS according the protocol established by Demeulemeester et al. (2011) using five Lebanese specimens collected as follows: 1 male from Tannourine Reserve Gate Area (34°12’27.9”N 35°55’56.9”E, 1796 m) and 4 males from Tannourine Reserve Trail 4 (35°55’56.9”N 35°55’56.0”E, 1781 m). All details of the methodology are presented in supporting information (Appendix S1). We assessed CLGS differentiations of the 5 Lebanese specimens to the 9 Sicilian Bombus terrestris calabricus of the same cluster using a multiple response permutation procedure (MRPP) (R-package vegan, Oksanen et al. 2011).

Results

A total of 269 specimens and field observations were assembled from the following sources: 11 from Base de données Gembloux et Mons, 12 from AUB, and 7 from USEK collections, 116 from the Mira Boustani collection, 83 from the Pierre Rasmont collection, and 39 from the Wael Yammine individual collections. Details of the specimens examined from the AUB and USEK collections are listed in Table 1.

Four species of Bombus were identified: B. niveatus vorticosus (Kriechbaum, 1870) (55 specimens, Figure 1a), B. terrestris (Linnaeus, 1758) (164 specimens, Figure 1b), B. argillaceus (Scopoli, 1763) (28 specimens, Figure 1c) and B. melanurus (Lepeletier, 1836) (21 specimens, Figure 1d).

Bombus terrestris (Linnaeus, 1758)

Species distribution. Centered on the Mediterranean (except Egypt) stretching north to Stockholm and east to Altai (Rasmont et al. 2008, 2015; Rasmont & Iserbyt 2010-2014).

Local distribution. Figure 2b. 27♀, 90♂, 46♂, 2 sex not specified: Ehden (5♀, 37♂, 5♂), Fatri (1♀), Arsoun (2♀, 1♂), Qartaba (1♀), Arz Bcharre (5♀, 5♂, 7♂), Qannoubine (1♂), Dahr El Adib (2♂), Qornet El Sawda (1♀, 3♂), Arz Tannourine (1♀, 2♂, 12♂), Harissa (1♀), Batroun (1♀), Falougha (2♂), Aley (1♀), Maameltein (1♀), Ammiq (3♀, 1♂), Qnat (5♀), Qornayel (1♂), Jouineh (1♀), Baskinta (3♀, 1♂), Beit Chabab (4♂), Hboub (1♀), Halate (1♀), Bawarij (1♀), Sawfar (2♀), Hadath Al Jebbeh (11♀, 15♂, 16♂, 2 unknown).

Altitude range in Lebanon. From sea level (Maameltein) to 3000 m (Qornet El Sawda).

Table 1. Details of specimens of Bombus examined from American University of Beirut (AUB) and Holy Spirit University of Kaslik (USEK).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Sex</th>
<th>Collector</th>
<th>Collection</th>
<th>Date</th>
<th>Locality</th>
<th>Governorate</th>
<th>Altitude</th>
</tr>
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<td>USEK</td>
<td>2.V.2016</td>
<td>Arsoun</td>
<td>Mount Lebanon</td>
<td>640</td>
</tr>
<tr>
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<td>♂</td>
<td>Boustani M.</td>
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<td>Bcharre Forest</td>
<td>North Lebanon</td>
<td>1928</td>
</tr>
<tr>
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<td>USEK</td>
<td>19.VI.2016</td>
<td>Ehden</td>
<td>North Lebanon</td>
<td>1567</td>
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<td>Bcharre</td>
<td>North Lebanon</td>
<td>2723</td>
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<td>Mount Lebanon</td>
<td>Mount Lebanon</td>
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<td>Arsoun</td>
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<td>640</td>
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<td>Wadi Quannoubine</td>
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Local distribution. Figure 2c. 1♀, 9♀, 1♂, 1 sex not specified: Ainata Al Arz (3♀), Ainoura (1♀), Arsoun (1♀), Arz Tannourine (1♀), Baskinta (1♀), Bcharre (2♀, 1♂), Bhamdoun (1♀), Dahr El Baidar (1♀), Ehden (9♀), Hadath El Jebbe (2♀), Harissa (Tannourine) (1♀), Hlaiye (1♀), Qornael (1♀), Zahrai (1♀).

Altitude range in Lebanon. From 230 m (Aintoura) to 2332 m (Dahr el Adib).


Bombus argillaceus (Scopoli, 1763)

Species distribution. Eastern Mediterranean distribution, stretching North to Czech Republic (Rasmont & Iserbyt 2010-2014) East to Russia, and South to Israel (Ascher & Pickering 2018).

Bombus niveatus vorticosus (Kriechbaumer, 1870)

Species distribution. Centered on the Aegean Sea, reaching Eastern European Russia to the North, Spain to the West, Iran to the East, and Israel to the South (Rasmont et al. 2015).

Local distribution. Figure 2a. 10♀, 32♀, 10♂, 4 not specified: Ainata Al Arz (5♀, 27♀, 6♂), Arz Bcharre.
(♀, 4♂, 2♀, 1 unknown), Duhor Barnasa (♀), Ehden (♀), Fehta (♂), Mount Hermon (♂), Qartaba (♀).

Altitude range in Lebanon. From 1648 m (Qartaba) to 3000 m (Qornet El Sawda).


*Bombus melanurus* (Lepeletier, 1836)

Species distribution. Central Asia, reaching the Caucasus and Eastern Turkey to the East (Rasmont et al. 2015).

Local distribution. Figure 2d. 5♀, 10♂, 6♂: Qadisha (♀), Arz Bcharre (♀, 1♂, 1♂), Ainata Al Arz (♀, 9♂, 5♂).

Altitude range in Lebanon. From 1815 m (Bcharre Cedars) to 3000 m (Qornet El Sawda).


Distribution by governorate

Bumblebee species presence or absence in the Lebanese governorates is displayed in Table 2 from left to right. The governorates are shown on every map from west to
east and from north to south (Table 1) in order to highlight sampled areas and the ones that are still data deficient.

**Figure 2.** Distribution maps of the four *Bombus* species from Lebanon. 


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**Bombus terrestris subspecies**

The morphological criteria of the examined *Bombus terrestris* material suggest the subspecies *Bombus terrestris*
calabricus Krüger, 1958 as the yellow band of the thorax extends under the tegulae in addition to the color pattern (Rasmont et al. 2008). Furthermore, the cephalic labial gland secretions analysis provides preliminary evidence that the local subspecies may be *B. t. calabricus*. Indeed, the Lebanese specimens fall in the only cluster of the individuals identified as this subspecies when compared to the database of Lecocq et al. (2016) (Figure 3), the p-value of the MRPP analysis being >0.05; therefore, the difference is not significant, and the chemicals profiles match the Sicilian *B. t. calabricus* specimens.

### Discussion

**Distribution**

*Bombus terrestris* is newly recorded in Lebanon despite it being locally widespread. This species is one of the most common in the West Palearctic (Williams 2011), and is a common species in Mediterranean ecosystems (Potts et al. 2006). Regional data report its presence in Syria coastal area (Solaiman-Khaled et al. 2012), and in Israel and Jordan (Rasmont & Iserbyt 2010-2014). Therefore, its absence from any published records is possibly due to under-sampling of the region. We can also eliminate the possibility of its recent incursion due to introduction of colonies for agricultural use as our oldest specimens in the database date back to 1973 (Sawfar) from the AUB collection, well before any introduction of non-native *B. terrestris* in 2001 (FAO Representation in Lebanon 2011). *Bombus argillaceus* on the other hand has already been recorded from some localities; older records include Reinig (1939) and another from 1977, both collected in Bcharre (Base de données fauniques Gembloux et Mons). It has also been collected in a variety of different habitats locally including woodlands, pastures, grasslands and ruderal areas, with a local distribution spanning sea level to 2500 m, although Solaiman-Khaled et al. (2012) found it significantly less abundant than *B. terrestris* in Syrian coastal areas. Indeed, it can live in several habitat types and is a common forager in cultivated and natural

<table>
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<th>Beirut</th>
<th>Akkar</th>
<th>North Lebanon</th>
<th>Mount Lebanon</th>
<th>Nabatieh</th>
<th>Baalbek-Hermel</th>
<th>Beqaa</th>
<th>South Lebanon</th>
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<td>––</td>
<td>+</td>
<td>+</td>
<td>–</td>
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<td>+</td>
<td>+</td>
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<tr>
<td><em>B. melanurus</em></td>
<td>––</td>
<td>+</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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</tr>
<tr>
<td><em>B. niveatus vorticosus</em></td>
<td>––</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
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<tr>
<td><em>B. terrestris</em></td>
<td>––</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Figure 3.** Unweighted pair group method with arithmetic mean (UPGMA) cluster based on a correlation matrix calculated from the cephalic labial gland secretions matrix of *Bombus terrestris* taxa, *B. ignitus* and *B. xanthopus* data from Lecocq et al. (2016). The values near nodes are multiscale bootstrap resampling (only values N90 of main groups are shown). The Lebanese specimens are highlighted in red.
Bombus terrestris and B. argillaceus have broader distributions in Lebanon, contrasting with B. niveatus vorticosus and B. melanurus, that seem to be restricted in the higher altitudes. Bombus niveatus vorticosus has also been reported from several locations including Rmeich from 1870 (Rasmont, original data), Jabal Al Shaikh in 2010, and Bcharre in 1931 collected by Zerny (GBIF 2019). Despite these records from lower altitude villages, in our collections we only found specimens from altitudes above 1800 m. Bombus niveatus vorticosus is indeed typical to steppe areas (Rasmont et al. 2009) as in the alpine steppe regions of Mount Lebanon chain, where most of our specimens were found. This species is also one of the most abundant species in its distribution range (Özbek 2002; Rasmont et al. 2015). Bombus melanurus also has some older records and has been reported through one collected specimen by Monty (2004), and two from the BMNH collection with one specimen of unknown date from Qadisha valley and the other from 1931 from Bcharre. In Lebanon it is at the southernmost point of its distribution (Rasmont et al. 2009) and is found mainly in altitudes higher than 1500 m (Aslan 2003; Rasmont et al. 2009; An et al. 2011). Its presence is somewhat unexpected as the closest known population is in the Taurus Mountains in Turkey (Rasmont et al. 2009).

The GBIF dataset (2019) reports other species: Bombus fragrans, B. muscorum, B. sylvarum, B. maxillosus, B. subterraneus and B. zonatus from Jezzine in 1905, identified by Vogt and preserved in UiT, the Arctic University of Norway. The examination of the original labels of the material (Kjerrandsen J., pers. comm. 2019) showed that this is a misinterpretation of the original label “Jassian, Asia Minor” [currently Yasyan in Turkey (Konya)], and the locality is not Jezzine in Lebanon.

**Bombus terrestris subspecies**

The cephalic labial gland secretions analysis suggests that the Bombus terrestris subspecies found in Lebanon is Bombus terrestris calabricus, as suggested by the morphological criteria from Rasmont et al. (2008). The morphological criteria method for differentiating species level for Bombus has been criticized as insufficient, such as in the case of Bombus lucorum complex (Carolan et al. 2012), and in certain subspecies, e.g. the difference between Bombus terrestris calabricus and B. terrestris dalmatinus (Bertsch & Schweer, 2012). The CLGS on the other hand has allowed bumblebee species to be separated in certain cases (e.g. Lecocq et al. 2015b; Martinet et al. 2018), and has also been used to differentiate subspecies in B. terrestris (Lecocq et al. 2016). However, it remains difficult to rely solely on this method as individuals may present variability among age (Žáček et al. 2009), and for certain species such as Bombus montanus and B. ruderarius, for example, the differences are not conclusive (Terzo et al. 2005). Furthermore, Bertsch & Schweer (2012) add that differentiation is difficult through CLGS for the different B. terrestris subspecies. Therefore, it has often been used in an integrative taxonomy framework, alongside the sequencing method of the mitochondrial gene cytochrome C oxidase I (COI) region, COI (e.g. Williams et al. 2012; Lecocq et al. 2016; Williams et al. 2019), and in certain cases where the DNA evidence is not enough, it is necessary to find molecular markers in order to differentiate the subspecies (Cejas et al. 2018). On the other hand, the known distribution of the Bombus terrestris calabricus subspecies is Sicily and south Italy (Rasmont et al. 2008; Coppée 2010), and the identified subspecies closest to the area is Bombus terrestris dalmatinus from Turkey (Rasmont et al. 2008), and the records from Israel and Turkey (Rasmont & Iserbyt 2010-2014) do not provide any information on the subspecies. This suggests that the local Bombus terrestris subspecies may be an isolated population. Therefore, and with the current lack of information of the biogeography of Bombus terrestris subspecies in the East Mediterranean, the evidence in our case remains very circumstantial and a larger sampling over the whole altitudinal range in Lebanon and neighboring countries, in an integrative taxonomy framework, are necessary to confirm the subspecies identification.

**Flower resources**

Bombus terrestris remains the most polyphagous species, foraging on 26 flowering species based on our observations. Indeed, it is a species known to forage from a broad spectrum of flowers (Rasmont 1988; Aslan 2003; Monfared et al. 2007; Williams 2011), highlighting its importance as a wild pollinator and potential interest for agricultural rearing in Lebanon. Bombus argillaceus is equally polyphagous (Rasmont 1988; Rasmont & Flaggothier 1996; Monfared et al. 2007; Rasmont et al. 2015), with a preference for flowers with long corolla like Fabaceae (Rasmont et al. 2015). Bombus niveatus vorticosus is also a forager that visits a wide range of flowers but focuses mainly on Lamiaceae and Fabaceae (Rasmont & Flaggothier 1996; Monfared et al. 2007). This concurs with our results for the plant family preference, but the number of species foraged locally from our records is only five. Similarly, Bombus melanurus seems to have restricted preferences with five foraged plants recorded locally, this can be due to the distribution of B. niveatus vorticosus and B. melanurus above 2000 m in the Oromediterranean strip where fewer seasonal foraging plants are available.
**Primary climatic risk assessment and recommendations**

From a conservation perspective, the four species are of interest as they visit and are potential pollinators of a wide range of wild plants, of which several are endemic such as *Vicia canescens* Labill., *Stachys ehrenbergii* Boiss. and *Cousinia libanotica* D.C. This is especially relevant for *Bombus niveatus vorticosus* and *B. melanurus* that are found in areas of high plant endemism in Lebanon (Bou Dagher-Kharrat et al. 2018). *Bombus terrestris* does not appear to be at risk due to climate change as the current conditions are causing its expansion towards the north (Martinet et al. 2015); therefore, we can expect it to preserve its current wide distribution locally. Similarly, the future distribution predictions for *Bombus argillaceus* suggest an expansion and no risk (Rasmont et al. 2015), although it is legally protected in Hungary (Kosior et al. 2007). *Bombus niveatus vorticosus* predictions also suggest that it could expand beyond its distribution range (Rasmont et al. 2015); in Lebanon, however, it seems restricted to altitudes above 1800 m from our collected specimens. Given its current local distribution, this species may yet be locally vulnerable as it is close to its southernmost distribution limit and does not seem to be expanding towards coastal areas. *Bombus melanurus* on the other hand has the most restricted local distribution mostly in the Oro-Mediterranean strip, rendering it vulnerable to extreme climatic events. This is emphasized by its total isolation from its closest known population in Turkey (Rasmont et al. 2009). The isolated local distribution of *Bombus niveatus vorticosus* and *B. melanurus* could be the result of a climatic induced shift towards higher altitudes (Biella et al. 2017), especially in the case of *B. niveatus vorticosus* for which literature records come from lower altitudes than the author’s collections. All four species should be included in any conservation plan as these pollinators potentially play an important role in the local flower-pollinator network, with emphasis on *B. melanurus* that must be closely monitored through observation as it is easily recognizable. Furthermore, current *Bombus* rearing efforts for agricultural purposes should focus on local *B. terrestris* as to avoid foreign strain invasions and protect the local subspecies (Lecocq et al. 2015a; Cejas et al. 2018).

**Acknowledgements**

We would like to thank the people who facilitated our fieldwork; Challita Tanios (Director of Tannourine Cedar Nature Reserve), Sandra Koussa Saba (Director of Horch Ehden Nature Reserve), Charbel Tawk (Committee of the Cedar Forest Friends, Bcharre), Abdallah Hanna (General Manager at Anniq wetlands Reserve). We would also like to thank Baptiste Martinet (UMons) who provided the expertise for the cephalic labial gland secretions analysis. Finally, we thank Guillaume Ghisbain and Thomas Wood (UMons) who contributed with helpful advice and reading the manuscript. Maps were made using raster files prepared by Jonathan de Ferranti (Scotland), interactive coverage maps supplied by Christoph Hormann.

**Supplementary material**

Supplemental data for this article can be accessed here.

**References**


