GEA, FLORA ET FAUNA

A bee biodiversity hotspot in the Algars River (NE Iberian Peninsula): species checklist and new faunistic records

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Rebut: 17.10.2025. Acceptat: 16.11.2025. Publicat: 31.12.2025.

Abstract

Riparian ecosystems have received little attention from apidologists, but their study is essential to know the diversity and conservation status of bees as well as to evaluate and properly conserve the ecological value of these habitats. In this work, we sampled bees (Anthophila) from a 500 m stretch of the Algars River (municipalities of Arnes and Horta de Sant Joan, Tarragona province, Spain) during the peak flowering period in July and August, using plant-pollinator surveys. A total of 107 bee species were detected, representing approximately 10% of the diversity of the Iberian Peninsula, highlighting that this riparian ecosystem is a biodiversity hotspot and a refuge for bees in summer, when floral resources in adjacent terrestrial ecosystems are scarce. The bee community stands out for the presence of rare (*Hylaeus nigrifacies*) or very abundant (*Ceratina* spp.) taxa which are strongly associated with floral and nesting resources (*e.g.* reed beds) present in riparian ecosystems. New faunistic records are provided for the Iberian Peninsula (including the first record of *Tetralonia alticincta*) and, at the regional level, first records of eight species in Catalonia, NE Spain: *Hylaeus dilatatus*, *H. kahri*, *H. lineolatus*, *H. pictipes*, *Nomiapis paulyi*, *Lasioglossum medinai*, *Sphecodes longulus*, *Tetralonia salicariae*. Two habitats of community interest are present in the study area, and two potentially threatened bee species have been detected (*Epeolus cruciger* and *Lasioglossum brevicorne*). The present study highlights the ecological value of riparian ecosystems for wild bees, and due to the extraordinary results obtained, we propose the creation of a pollinator nature reserve in the studied section of the Algars River, following the recommendations of the European legislation as well as those from regional pollinator conservation plans.

Keywords: Anthophila, *Tetralonia alticincta*, Mediterranean, Iberian Peninsula, riparian ecosystems, endangered species

Resum

Un punt calent de biodiversitat d'abelles al riu Algars: *checklist* d'espècies i novetats faunístiques

Els ecosistemes riparis han rebut històricament poca atenció per part dels apidòlegs, però el seu estudi és essencial per a conèixer la diversitat i l'estat de conservació de les d'abelles, així com per a avaluar i conservar correctament el valor ecològic d'aquests hàbitats. En aquest treball s'han mostrejat les abelles (Anthophila) d'un tram de 500 m del riu Algars (municipis d'Arnes i Horta de Sant Joan, província de Tarragona, Espanya) durant el pic de floració dels mesos de juliol i agost, mitjançant censos planta-pol·linitzador. S'hi van detectar 107 espècies d'abelles, que representa aproximadament un 10% de la diversitat d'abelles de la Península Ibèrica, posant de manifest que aquest ecosistema ripari és un punt calent de biodiversitat i un refugi per a les abelles durant l'estiu, quan els recursos florals dels ecosistemes terrestres adjacents són escassos. La comunitat d'abelles destaca per la presència de tàxons rars (*Hylaeus nigrifacies*) o molt abundants (*Ceratina* spp.) fortament associats a recursos florals i de nidificació (*e.g.* canyissars) presents en ecosistemes riparis. S'hi aporten novetats faunístiques per a la Península Ibèrica (inclosa la primera cita de *Tetralonia alticincta*) i, a nivell regional, les primeres cites de vuit espècies a Catalunya, NE Espanya: *Hylaeus dilatatus*, *H. kahri*, *H. lineolatus*, *H. pictipes*, *Nomiapis paulyi*, *Lasioglossum medinai*, *Sphecodes longulus*, *Tetralonia salicariae*. A la zona estudiada hi són presents dos hàbitats d'interès comunitari, i s'hi han detectat dues espècies d'abelles potencialment amenaçades (*Epeolus cruciger* i *Lasioglossum brevicorne*). El present estudi posa de manifest el valor ecològic dels ecosistemes riparis per a les abelles silvestres. Atès els resultats extraordinaris obtinguts, es proposa la creació d'una reserva natural per a pol·linitzadors al tram estudiat del riu Algars, seguint les recomanacions de la legislació europea i els plans regionals de conservació de pol·linitzadors.

Paraules clau: Anthophila, *Tetralonia alticincta*, mediterrani, península Ibèrica, ecosistemes riparis, espècies amenaçades.

Introduction

Pollinators are a group of taxonomically very diverse organisms that play a central role in ecosystems, ensuring the pollination of more than 85% of wild flowering plants and more than 75% of crops at a global scale (Klein *et al.*, 2007, Ollerton *et al.*, 2011). The most important group of pollinators is bees (Proctor *et al.*, 1996), as their life cycle is closely linked to flowers. In the Iberian Peninsula there are about a thousand species (Ortiz-Sánchez, 2020). In Catalonia, about seven hundred species are known, although the exact number is unknown (Bartomeus *et al.*, 2022).

In Mediterranean ecosystems, habitats favorable to bees are those characterized by their high degree of openness and insolation, where floral communities can develop, such as meadows or scrublands (Wiesbauer, 2020). Some of these habitats appear as a result of natural dynamics (*e.g.* fires or herbivory by large wild herbivores), and others as a result of disturbances or anthropogenic uses (crops, pastures, etc.). Due to the process of rural abandonment and afforestation of the territory (Palmero-Iniesta *et al.*, 2020), in recent years there has been a reduction in these open spaces. This regional phenomenon is added to the set of processes related to global change (agricultural intensification, invasions of exotic species, etc.) that cause serious dangers for the conservation of pollinators (Vanbergen *et al.*, 2013).

All these habitats are part of terrestrial ecosystems, and this is where most efforts have been focused on the study of wild bees (*e.g.* Reverté *et al.*, 2019). Riparian habitats, which form a transition between terrestrial and aquatic ecosystems, are home to a multitude of taxonomic groups and are extremely important for the functioning of waterways (Naiman *et al.*, 1993). However, research on bee communities in this type of habitat is scarce (but see Williams, 2011), and non-existent in our region. This lack of knowledge is particularly alarming because in Mediterranean ecosystems riparian and terrestrial habitats are completely different in terms of the composition and phenology of floral communities. Because flower communities and bee communities are closely related (Potts *et al.*, 2003), it is expected that riparian habitats harbour distinct and unknown species.

Therefore, knowing the bee communities of riparian habitats is necessary for 1) correctly assess the diversity of bees in the region, 2) to allow the assessment of the conservation status of particularly rare bee species (Nieto *et al.*, 2014), 3) highlight freshwater ecosystems and riparian vegetation as biodiversity refuges, especially during the dry period in the Mediterranean area, and 4) to stimulate the conservation of these ecosystems and of characteristics such as the ecological flow of rivers, especially under a climate change scenario with more episodes of extreme drought usually coupled with heat waves (Vogel *et al.*, 2021).

This study contains a list of all bee species documented in a riparian ecosystem of the Algars River between July and August 2024.

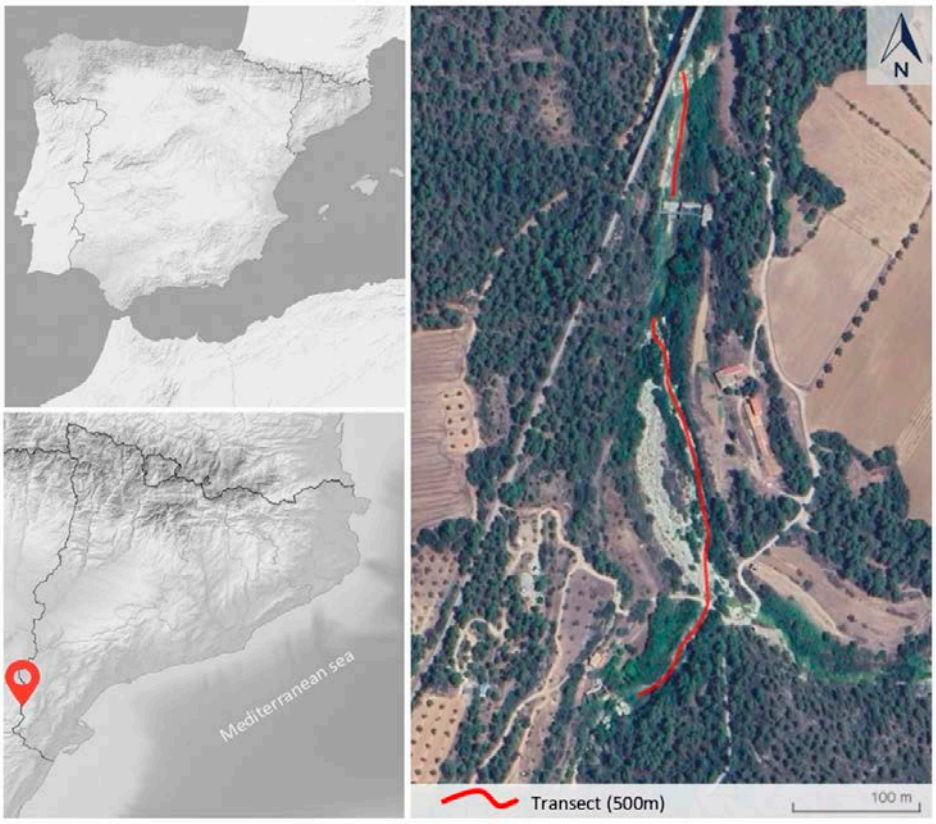

Figure 1. Study area, with the transect where plant-pollinator surveys were carried out.

Figure 2. Habitat where the sampling was carried out, characterized by the blooming of *Lythrum salicaria*.

Materials and Methods

Study area

The study was carried out on the banks of the Algars River (municipalities of Arnes and Horta de Sant Joan, Terra Alta, Catalonia, Spain, 40°56′10.75″N 0°16′27.10″E; Fig. 1), in a riparian ecosystem that is part of the Natura 2000 Network, at an altitude of 415 meters above sea level (Topographic Map of Catalonia 1:50.000, Institut Cartogràfic i Geològic de Catalunya, 2024). The climate is Mediterranean continental, with an average annual precipitation of 614 mm and an average annual temperature of 15°C (Departament d'Agricultura, Ramaderia, Pesca i Alimentació, 2024). The river valley is wide and oriented north–south, crossing an extensive agricultural landscape dominated by olive groves. The Algars River presents oligotrophic water conditions and flows on alkaline substrates, including limestone conglomerates and fine-grained sedimentary rocks. During summer, parts of the river become disconnected as many of its sources dry up, leaving only a few sections with flowing water. The average river flow at this point is about 0.8 m^3/s (Confederación Hidrográfica del Ebro, 2024). The riparian vegetation is typical of non-permanent Mediterranean riparian forests and is in a good state of conservation. It is dominated by willows (*Salix* spp. L., 1753), which have a sparse tree and shrub layer, and are characterized by a rich herbaceous substrate of hydrophytic and hydrophilic plants such as *Lythrum salicaria* L., 1753, *Epilobium* spp. L., 1753 and *Mentha* spp. L., which bloom in summer (Fig. 2).

Experimental design and sampling

We established a 500 m transect that encompassed all flowering plant species present in the riparian ecosystem. Plant-pollinator surveys were carried out along the transect to record interactions between flowering plant species and floral visitors. Each survey consisted of visually scanning all the flowers in the transect and recording the number of times each bee species contacted the reproductive organs of each flowering plant species. The list of flowering plant species is included in the Appendix 1. This methodology is widely used to characterize pollinator communities (*e.g.*, Reverté *et al.* 2019). The surveys were carried out in 2024, during the flowering peak of the community, from July 19th to August 13th. We conducted eight surveys, ~two surveys per week. The surveys were carried out under conditions suitable for pollinator activity (on sunny, windless days, and with a temperature above 15°C), and generally between 9 am and 3 pm (solar time 7am - 1pm). During the surveys at least one specimen of each bee species observed was collected for subsequent identification at species level in the laboratory.

Sample processing and taxonomic identification

The bee samples were transferred and properly preserved in entomological collections, which are deposited in the laboratory of the Wildlife Ecology & Health Group, at the Faculty of Veterinary Medicine of the Autonomous University of Barcelona (https://weh.cat/). All bees were identified to the species level, following the references included in the Appendix 2, and classified according to Ghisbain *et al.* (2023), the most up-to-date and comprehensive source currently available for European wild bee species.

A binocular stereo microscope model AmScope SM-1TSZZ-144S-10M-3PL (3.5-180x) was used to study specimens. For males, the genital capsule was extracted by placing the pinned specimen in a steam chamber for 30 minutes to soften the tissues. The metasoma was then held against a foam surface with a toothpick in one hand, while the capsule was carefully removed using a needle bent at the tip.

Results

In the list presented below, we compiled all the species identified in this study, along with their currently recognized status. In total, we detected 107 species.

Family **Andrenidae** Latreille, 1802
Tribe **Andrenini** Latreille, 1802

Genus *Andrena* Fabricius, 1775
incertae sedis
Andrena hypopolia Schmiedeknecht, 1884
Subgenus *Plastandrena* Hedicke, 1933
Andrena bimaculata (Kirby, 1802)

Tribe **Panurgini** Leach, 1815

Genus *Panurgus* Panzer, 1806
Subgenus *Panurgus* Panzer, 1806
Panurgus calcaratus (Scopoli, 1763)
Panurgus cephalotes Latreille, 1811

Family **Apidae** Latreille, 1802
Tribe **Ammobatini** Handlirsch, 1925

Genus *Pasites* Jurine, 1807
Pasites maculatus Jurine, 1807

Tribe **Anthophorini** Dahlbom, 1835

Genus *Amegilla* Friese, 1897
Subgenus *Amegilla* Friese, 1897
Amegilla garrula (Rossi, 1790)
Amegilla quadrifasciata (de Villers, 1789)
Subgenus *Zebramegilla* Brooks, 1988
Amegilla albigena (Lepeletier, 1841)

Tribe **Apini** Latreille, 1802

Genus *Apis* Linnaeus, 1758
Subgenus *Apis* Linnaeus, 1758
Apis mellifera Linnaeus, 1758

Tribe **Bombini** Latreille, 1802

Genus *Bombus* Latreille, 1802
Subgenus *Bombus* Latreille, 1802
Bombus terrestris (Linnaeus, 1758)
Subgenus *Melanobombus* Dalla Torre, 1880
Bombus lapidarius (Linnaeus, 1758)

Tribe **Ceratinini** Latreille, 1802

Genus *Ceratina* Latreille, 1802
Subgenus *Ceratina* Latreille, 1802
Ceratina cucurbitina (Rossi, 1792)
Subgenus *Dalyatina* Terzo, 2007
Ceratina parvula Smith, 1854
Subgenus *Euceratina* Hirashima, Moure & Daly, 1971
Ceratina callosa (Fabricius, 1794)
Ceratina chalcites Germar, 1839
Ceratina chalybea Chevrier, 1872
Ceratina cyanea (Kirby, 1802)
Ceratina dallatorreana Friese, 1896
Ceratina dentiventris Gerstaecker, 1869
Ceratina gravidula Gerstaecker, 1869
Ceratina mocsaryi Friese, 1896
Ceratina nigrolabiata Friese, 1896

Tribe **Epeolini** Robertson, 1903

Genus *Epeolus* Latreille, 1802
Epeolus cruciger (Panzer, 1799)

Tribe **Eucerini** Latreille, 1802

Genus *Tetralonia* Spinola, 1839
Tetralonia alticincta (Lepeletier, 1841)
Tetralonia salicariae (Lepeletier, 1841)

Tribe **Melectini** Westwood, 1839

Genus *Thyreus* Panzer, 1806
Thyreus histrionicus (Illiger, 1806)
Thyreus ramosus (Lepeletier, 1841)

Tribe **Xylocopini** Latreille, 1802

Genus *Xylocopa* Latreille, 1802
Subgenus *Copoxyla* Maa, 1954
Xylocopa iris (Christ, 1791)
Subgenus *Xylocopa* Latreille, 1802
Xylocopa violacea (Linnaeus, 1758)

Family **Colletidae** Lepeletier, 1841
Tribe **Colletini** Latreille, 1802

Genus *Colletes* Latreille, 1802
Colletes acutus Pérez, 1903
Colletes nigricans Gistel, 1857

Tribe **Hylaeini** Viereck, 1916

Genus *Hylaeus* Fabricius, 1793
Subgenus *Dentigera* Popov, 1939
Hylaeus brevicornis Nylander, 1852
Hylaeus imparilis Förster, 1871
Hylaeus kahri Förster, 1871
Subgenus *Hylaeus* Fabricius, 1793
Hylaeus angustatus (Schenck, 1861)
Hylaeus communis Nylander, 1852
Hylaeus leptocephalus (Morawitz, 1870)
Hylaeus nigrifacies Bramson, 1879
Subgenus *Lambdopsis* Popov, 1939
Hylaeus dilatatus (Kirby, 1802)
Subgenus *Paraprosopis* Popov, 1939
Hylaeus clypearis (Schenck, 1853)
Hylaeus lineolatus (Schenck, 1861)
Hylaeus pictipes Nylander, 1852
Subgenus *Prosopis* Fabricius, 1804
Hylaeus gibbus Saunders, 1850
Hylaeus pictus (Smith, 1853)
Hylaeus purpurissatus (Vachal, 1895)
Hylaeus variegatus (Fabricius, 1798)
Subgenus *Spatulariella* Popov, 1939
Hylaeus hyalinatus Smith, 1842
Hylaeus punctatus (Brullé, 1832)

Family **Halictidae** Thomson, 1869
Subfamily **Halictinae** Thomson, 1869

Genus *Halictus* Latreille, 1804
Subgenus *Hexataenites* Pesenko, 1984
Halictus cochleariatarsis (Dours, 1872)
Halictus fulvipes (Klug, 1817)
Halictus scabiosae (Rossi, 1790)
Subgenus *Monilapis* Cockerell, 1931
Halictus compressus (Walckenaer 1802)
Genus *Lasioglossum* Curtis, 1833
Subgenus *Hemihalictus* Cockerell, 1897
Lasioglossum brevicorne (Schenck, 1868)
Lasioglossum buccale (Pérez, 1903)
Lasioglossum griseolum (Morawitz, 1872)

Lasioglossum ibericum Ebmer, 1975
Lasioglossum limbellum (Morawitz, 1876)
Lasioglossum lucidulum (Schenck, 1861)
Lasioglossum medinai (Vachal, 1895)
Lasioglossum minutissimum (Kirby, 1802)
Lasioglossum pseudoplanulum (Blüthgen, 1924)
Lasioglossum punctatissimum (Schenck, 1853)
Lasioglossum sphecodimorphum (Vachal, 1892)
Lasioglossum strictifrons (Vachal, 1895)
Lasioglossum transitorium planulum (Pérez, 1903)
Lasioglossum truncaticolle (Morawitz, 1877)
Lasioglossum villosulum (Kirby, 1802)
Subgenus *Lasioglossum* Curtis, 1833
Lasioglossum sexnotatum (Kirby, 1802)
Subgenus *Leuchalictus* Warnke, 1975
Lasioglossum albocinctum (Lucas, 1849)
Lasioglossum discus (Smith, 1853) [*L. discus discus* (Smith, 1853) and *L. discus fertoni* (Vachal, 1895)]
Lasioglossum leucozonium (Schrank, 1781)
Subgenus *Pyghalictus* Warncke, 1975
Lasioglossum glabriusculum (Morawitz, 1872)
Lasioglossum politum (Schenck, 1853)
Subgenus *Sphecodogastra* Ashmead, 1899
Lasioglossum interruptum (Panzer, 1798)
Lasioglossum malachurum (Kirby, 1802)
Lasioglossum mediterraneum (Blüthgen, 1926)
Lasioglossum nigripes (Lepeletier, 1841)
Lasioglossum pauxillum (Schenck, 1853)
Genus *Seladonia* Robertson, 1918
Subgenus *Seladonia* Robertson, 1918
Seladonia gemmea (Dours, 1872)
Seladonia smaragdula complex*
Seladonia subaurata (Rossi, 1792)
Subgenus *vestitohalictus* Blüthgen, 1961
Seladonia vestita (Lepeletier, 1841)
Genus *Sphecodes* Latreille, 1804
Sphecodes longulus Hagens, 1882

Subfamily **Nomiinae** Robertson, 1904

Genus *Nomiapis* Cockerell, 1919
Nomiapis diversipes (Latreille, 1806)
Nomiapis paulyi Wood & Le Divelec, 2022

Subfamily **Nomioidinae** Börner, 1919

Genus *Ceylalictus* Strand, 1913
Ceylalictus variegatus (Olivier, 1789)

Family **Megachilidae** Latreille, 1802
Tribe **Anthidiini** Ashmead, 1899

Genus *Anthidiellum* Cockerell, 1904
Anthidiellum strigatum (Panzer, 1805)
Genus *Anthidium* Fabricius, 1804
Subgenus *Anthidium* Fabricius, 1804
Anthidium florentinum (Fabricius, 1775)
Anthidium loti Perris, 1852
Anthidium manicatum (Linnaeus, 1758)
Genus *Stelis* Panzer, 1806
Subgenus *Protostelis* Friese, 1895
Stelis signata (Latreille, 1809)
Subgenus *Stelis* Panzer, 1806
Stelis breviuscula (Nylander, 1848)
Stelis punctulatissima (Kirby, 1802)

Tribe **Megachilini** Latreille, 1802

Genus *Coelioxys* Latreille, 1809
Subgenus *Allocoelioxys* Tkalců, 1974
Coelioxys brevis Eversmann, 1852
Coelioxys echinatus Förster, 1853
Subgenus *Paracoelioxys* Gribodo, 1884
Coelioxys elongatus Lepeletier, 1841
Genus *Megachile* Latreille, 1802
Subgenus *Callomegachile* Michener, 1962
Megachile sculpturalis Smith, 1853
Subgenus *Eutricharaea* Thomson, 1872
Megachile argentata (Fabricius, 1793)
Megachile apicalis Spinola, 1808
Subgenus *Megachile* Latreille, 1802
Megachile centuncularis (Linnaeus, 1758)
Megachile melanopyga Costa, 1863
Megachile octosignata Nylander, 1852
Subgenus *Xanthosarus* Robertson, 1903
Megachile lagopoda (Linnaeus, 1761)
Megachile maritima (Kirby, 1802)

Tribe **Osmiini** Newman, 1834

Genus *Heriades* Spinola, 1808
Subgenus Heriades Spinola, 1808
Heriades crenulata Nylander, 1856
Heriades rubicola Pérez, 1890
Heriades truncorum (Linnaeus, 1758)

Discussion

In the studied stretch of the Algars River, 107 species of bees were recorded, approximately 10% of all the diversity known from the Iberian Peninsula (Ortíz-Sánchez, 2020). This result is surprising considering that this diversity has been found within just a 500 m stretch and during only one month of sampling in summer. Therefore, we can affirm that the study area in the Algars River is a biodiversity hotspot

* *Seladonia smaragdula* complex is a species complex that in Catalonia includes *Seladonia smaragdula* (Vachal, 1895), *Seladonia submediterranea* Pauly, 2015, and perhaps *Seladonia gemmella* Pauly, 2015 (see Pauly *et al.*, 2015) with indistinguishable females and which are only separated by males.

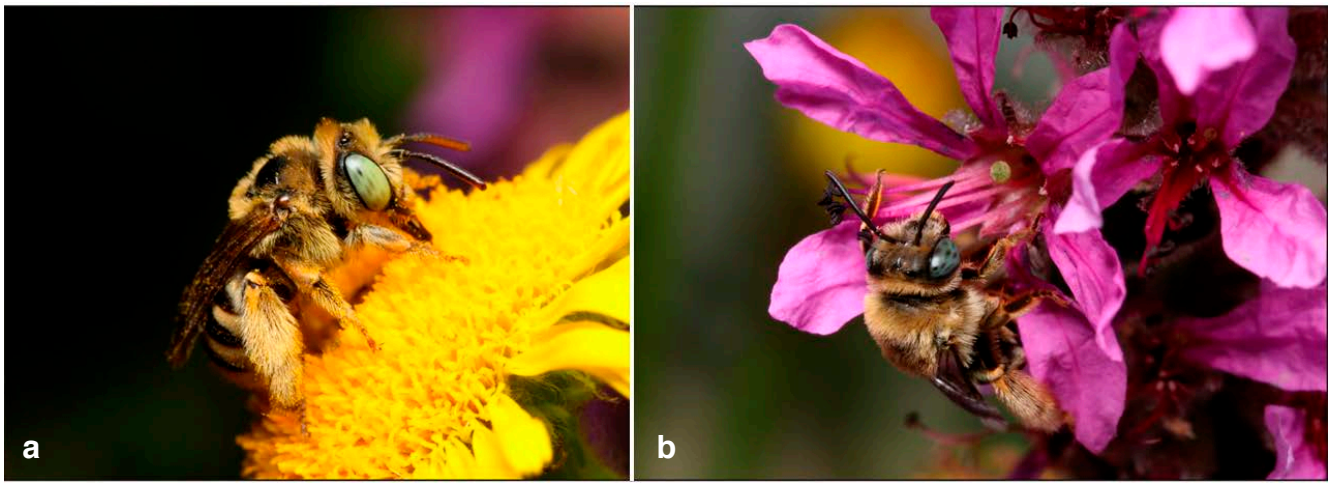

Figure 3. Females of a) *Tetralonia alticincta* (collecting pollen on *Pulicaria dysenterica*) and b) *Tetralonia salicariae* (collecting pollen on *Lythrum salicaria*). Both species are pollen specialists on plants inhabiting riparian ecosystems, and were detected in the present study, representing first records for the Iberian Peninsula (*T. alticincta*) and Catalonia (NE Spain) (*T. salicariae*). Photo credits: José Luís Romero.

for bees. Furthermore, this area also represents a biodiversity refuge for bees in the summer months, where adjacent terrestrial ecosystems offer few floral resources, resulting in simplified wild bee communities (Guerrero *et al.*, in preparation). The function of rivers as biodiversity refuges for bees will become more important over time due to the consequences of climate change, such as recurrent droughts (Seavy *et al.*, 2009; Skoulikidis *et al.*, 2017). In this sense, the continuous presence of water, the abundance and diversity of floral resources in summer, and the huge amount of nesting substrates, can support an extremely complex community, comprising both common species and rare, idiosyncratic ones typical of riparian ecosystems.

The bee *Tetralonia alticincta* (Apidae: Eucerini), a mining bee with dietary specialization on pollen of *Pulicaria dysenterica* (L.) Bernh. and closely linked to freshwater ecosystems (Müller, 2008; Wiesbauer, 2020), is mentioned in this study for the first time in the Iberian Peninsula (see Fig. 3a). In the Mediterranean, riparian ecosystems host flowering plants characteristic of humid ecosystems in Central Europe (Stella *et al.*, 2013). Thus, the exploration of these ecosystems may surely lead to the discovery of new faunistic records, especially for those species closely associated with flowering plants. In addition, and according to the available bibliography, including Bartomeus *et al.* (2022) and the GBIF repository (GBIF.org, 2025), the following eight species are mentioned for the first time in the region of Catalonia (NE Spain): *Hylaeus dilatatus*, *H. kahri*, *H. lineolatus*, *H. pictipes*, *Nomiapis paulyi*, *Lasioglossum medinai*, *Sphecodes longulus*, *Tetralonia salicariae*. In relation to the above-mentioned prediction, *T. salicariae* is a pollen specialist on *Lythrum* (L.) (Dorchin & Michez, 2024), a plant associated with riparian ecosystems (see Fig. 3b). Regarding *N. paulyi*, this species is not included in the checklist of the bees from the Iberian Peninsula (Ortíz 2020) because it has been recently described with specimens from Portugal and central and southern Spain (Wood & LeDivelec, 2022).

Besides hosting flowering communities different from those of terrestrial ecosystems, riparian ecosystems also host distinct nesting substrates available to a wide variety of wild solitary bees. This is especially true for the great abundance of plants with pithy stems that can be used by cavity-nesting and carpenter bees. Because nesting resources also structure bee communities (Potts *et al.*, 2005), this may also yield different bee communities in riparian ecosystems. We detected the cellophane bee *Hylaeus nigrifacies* (Colletidae), an extremely rare species with few published records in the Iberian Peninsula and Catalonia (Romain Le Divelec, com. pers.), which nests in stems of *Phragmites* Adans., 1763 (Ornosa & Ortiz-Sánchez, 2004). Importantly, we detected 11 of the 13 species of the genus *Ceratina* (Apidae: Xylocopinae) present in the Iberian Peninsula. These carpenter bees are relatively abundant in our study system, apparently due to the high abundance of *Epilobium* spp. flowers (Onagraceae), for which they show a great preference, but clearly as a consequence for the great abundance and diversity of potential nesting substrates, such as stems of *Rubus* L., 1753, *Cirsium* Mill., 1754, *Dipsacus* L., 1753 *Verbascum* L., 1753, *Foeniculum* Miller, *Phragmites*, and *Scirpus* L., 1753 (Aguado Martín *et al.*, 2015).

We detected the invasive bee *Megachile sculpturalis* Smith, 1853 (Megachilidae), better known as the giant resin bee. One male was captured feeding on the nectar of *Lythrum salicaria*, probably a specimen dispersed from nearby towns where established populations occur (Lanner *et al.*, 2022).

Implications for conservation

Two potentially threatened species are detected according to the Red List of European Bees (Nieto *et al.*, 2014): the kleptoparasitic bee *Epeolus cruciger*, and the mining bee *Lasioglossum brevicorne*, both species under the Near Threatened category. *E. cruciger* parasitizes bees of the genus *Colletes* (also miner bees), while the ecology of *L. brevicorne* is

less well known (Naturalis Biodiversity Center, 2025). Actions to foster populations of these two species must be focused on ensuring the abundance of hosts (*Colletes*) and floral resources in general, given the polylectic nature of *Colletes* and *Lasioglossum*. Slopes and bare soil of adjacent terrestrial habitats must be conserved as potential nesting substrates for these species.

The study area presents three habitats: Western Mediterranean purple willow scrub (*Salix* spp.), Mediterranean tall humid grassland, and intermittent Mediterranean rivers with nitrophilous grasses (Aymerich *et al.*, 2014; Generalitat de Catalunya 2025). The last two habitats are considered as Habitats of Community Interest (Council Directive 92/43/EEC: EU-EC (1992; 2013). This classification requires specific conservation measures to ensure the conservation of these habitats.

Conclusions: towards the creation of a nature reserve for pollinators

This study demonstrates that riparian ecosystems can host a great diversity of bees, and the new faunal discoveries highlight the lack of knowledge about this type of habitat. Further research is therefore needed in inland aquatic ecosystems, especially for those groups of organisms, such as pollinators, that have traditionally been studied in terrestrial ecosystems. In fact, our results exceed our expectations, and we can conclude that the Algars River is both a biodiversity hotspot and a biodiversity refuge for bees, and all these features make this ecosystem a target for conservation, according to the criteria of the European Pollinators Initiative (EU-EC, 2023).

For this reason, we propose this space to be included in the cartography of natural and semi-natural places of great relevance for the conservation of wild pollinators in the region of Catalonia (NE Spain), and the establishment of a nature reserve aimed at conserving wild bee populations, following the indications of measures 4A and 4B of the PIPOL project (Departament de Territori, Habitatge i Transició Ecològica, 2024).

The Algars River is part of a large basin (Ebro), and its flow remains relatively high and largely unregulated. This probably explains why the riparian ecosystem is relatively open and heterogeneous, without a continuous cover of riparian forest. Management measures aimed at conserving the habitats and the wild bees present must guarantee that the ecological integrity is, at least, that which exists now, within the riverbank as well as in adjacent terrestrial ecosystems. Natural ecosystem dynamics must therefore be conserved and, if needed, restored. Hydrological dynamics must be guaranteed by intervening as little as possible in the flow of the river. The capture and retention of water in dams and reservoirs can prevent ecological flow in certain periods of the year and make it difficult to flood and disturb the riverbeds that create and maintain semi-open spaces that bees inhabit. In this sense, afforestation of the riverbed should be avoided, especially if it occurs continuously and by non-riparian or invasive elements. A paradigmatic example of this risk is that of *Populus* spp. productive plantations, very common along the riverbanks of the Ebro basin (Ministerio para la Transición Ecológica y el Reto Demográfico, 2023), sometimes enhanced by carbon stock credit banks. More research must be conducted to reveal if non-altered hydrological dynamics are the main mechanism behind high bee biodiversity in riparian ecosystems.

The nature reserve should be parcelled out and labelled, although it is currently not crowded due to the difficulty of access. Finally, it is imperative that wild bee populations are monitored annually (during the flowering peak in summer) to evaluate their trends, especially for rare or threatened species.

Acknowledgements

We thank the Editor Prof. Juli Pujade-Villar, Leopoldo Castro and an additional anonymous reviewer for their constructive comments in the review process. We thank Alejandro Núñez-Carvajal (University of Oviedo) and Simone Flaminio (University of Mons) for discussion, advice, and confirmation of the new records of *Tetralonia alticincta* and *Nomiapis paulyi*, respectively. We thank Mariona Cuesta, Jorge López and Joan Pérez for their assistance in the sampling campaign in the field and in the sample processing in the laboratory. This study has been funded by the Parc Natural dels Ports.

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Appendix 1

List of flowering plant species recorded in the transect of the study area where plant-pollinator surveys were conducted.

Family **Apiaceae**
Daucus carota L., 1753
Foeniculum vulgare Mill., 1768
Helosciadium nodiflorum (L.) W.D.J.Koch, 1824
Torilis arvensis (Huds.) Link, 1822

Family **Asteraceae**
Cichorium intybus L., 1753
Cirsium monspessulanum (L.) Hill, 1768
Cirsium vulgare (Savi) Ten., 1835
Erigeron sumatrensis Retz., 1783
Eupatorium cannabinum L., 1753
Jacobaea vulgaris Gaertn., 1791
Lactuca saligna L., 1753
Lactuca serriola L., 1753
Leontodon longirostris (Finch & P.D. Sell) Talavera, 1982
Pulicaria dysenterica (L.) Bernh., 1800
Senecio vulgaris L., 1753
Sonchus arvensis L., 1753
Sonchus maritimus subsp. *aquatilis* (Hill) P.D. Sell, 1976
Sonchus oleraceus L., 1753
Sonchus tenerrimus L., 1753

Family **Boraginaceae**
Echium vulgare L., 1753

Family **Brassicaceae**
Diplotaxis erucoides (L.) DC., 1821
Hirschfeldia incana (L.) Lagr.-Foss.

Family **Caprifoliaceae**
Scabiosa atropurpurea L., 1753

Family **Convolvulaceae**
Calystegia sepium (L.) R.Br., 1810

Family **Euphorbiaceae**
Euphorbia hirsuta L., 1753
Euphorbia segetalis L., 1753

Family **Fabaceae**
Lotus corniculatus L., 1753
Lotus rectus L., 1753

Family **Gentianaceae**
Blackstonia perfoliata (L.) Huds., 1762
Centaurium pulchellum (Sw.) Druce, 1913

Family **Hypericaceae**
Hypericum tomentosum L., 1753

Family **Lamiaceae**
Lycopus europaeus L., 1753
Mentha longifolia (L.) L., 1762
Mentha longifolia × *Mentha suaveolens* (híbrid, sense autor formal)
Mentha pulegium L., 1753
Mentha suaveolens Ehrh., 1792
Nepeta cataria L., 1753
Satureja montana L., 1753
Teucrium chamaedrys L., 1753
Teucrium scordium L., 1753

Family **Lythraceae**
Lythrum salicaria L., 1753

Family **Malvaceae**
Althaea officinalis L., 1753

Family **Onagraceae**
Epilobium hirsutum L., 1753
Epilobium parviflorum Schreb., 1771

Family **Papaveraceae**
Papaver dubium L., 1753

Family **Plantaginaceae**
Antirrhinum barrelieri Pau, 1906
Veronica anagallis-aquatica L., 1753

Family **Polygonaceae**
Persicaria maculosa Gray, 1821

Family **Primulaceae**
Lysimachia arvensis (L.) U.Manns & Anderb., 2009
Lysimachia ephemerum L., 1753
Samolus valerandi L., 1753

Family **Rosaceae**
Rubus ulmifolius Schott, 1818
Sanguisorba minor Scop., 1771

Family **Rubiaceae**
Galium lucidum All., 1785

Family **Scrophulariaceae**
Scrophularia auriculata L., 1753
Verbascum sinuatum L., 1753

Family **Solanaceae**
Solanum dulcamara L., 1753

Family **Valerianaceae**
Centranthus angustifolius (Mill.) DC., 1805

Family **Verbenaceae**
Verbena officinalis L., 1753

Appendix 2

List of taxonomic references used in this study to identify bee specimens.

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