

Since 2015, the first solitary bee hotels in Sicily located in the small island of Isola delle Femmine Nature Reserve, Sicily (Italy)

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ABSTRACT

Natural pollinators, mainly represented by solitary apoidea, play an essential role in ecosystems and biodiversity. Their population has sharply declined recently, putting both flora and fauna biodiversity at risk. Many studies report that artificial nesting for reproducing solitary bees, also known as bee hotels, can support conservation and increase the number of pollinators. Unipa and LIPU Isola delle Femmine Nature Reserve wanted to create the first bee hotels in 2015 near the coast. In particular, the goal of this project was to protect and increase biodiversity on the islet of Isola delle Femmine, a peculiar and challenging to-balance environment where there are more than 200 botanical taxa present on the island, some of which are endemic to Sicilian north-western coast, including pollination by insects. In the current state of knowledge, it is the first case of installing bee hotels in a coastal area so close to the sea, which entailed a significant technical challenge in the construction using recycled material. The hotels built were wholly colonized in a very short period, and even when maintenance and replacement of materials were carried out in less than a week, the recolonization was rapid. Most individuals belonged to the Megachilidae family, which is characteristic of the Mediterranean. The bee hotels have also been a source of curiosity and insight for the reserve visitors. In conclusion, the bee hotel proved useful for colonizing pollinators and increasing reserve use.

KEY WORDS

Conservation; bee hotels; nature reserve; pollinators; solitary bees.

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INTRODUCTION

A global decline in the number of honey bees and wild pollinators has elicited considerable public attention. Pollination is among the most critical ecosystem services for plant reproduction and affects human survival (Schowalter, 2022). It is car-

ried out partly by the wind and primarily by animals, such as pollinator insects, mainly represented by the orders Hymenoptera, Lepidoptera, and Coleoptera (Kevan & Baker, 1983).

Solitary bees are considered excellent crop pollinators (Williams, 2002; Shuler et al., 2005; Klein et al., 2007), and their presence and density are

linked to floristic biodiversity (Johnson et al., 2022). They play a pivotal role in the formation and conservation of the environment, and it is also well-known that they are vital for maintaining ecological balance and biodiversity (Brown & Paxton). Several studies have shown the importance of wild bees to our ecosystems and how they could collapse without the indispensable contribution of these insects (Potts et al., 2010). Sudden climate change, pollution, and the uncontrolled use of insecticides, but also carelessness and ignorance, lack of respect, and fear for these insects are just some of the causes that are driving the honeybee population into a decline (Berkes & Turner, 2006; Dicks et al., 2021; European Parliament, 2021). Therefore, ensuring the well-being of honeybees is a crucial component of fostering sustainability and ecosystem services.

Wild bee populations can become highly abundant when large areas are maintained with floristic biodiversity (Kremen et al., 2004; Potts et al., 2010; Abrol, 2012) and with rich nest varieties and locations. On the contrary, small areas such as Isola delle Femmine (Sicily, Italy) can reduce biodiversity and create difficulties in conservation strategies to maintain biodiversity. Conservation policies tend to favor large patches and may, therefore, lead to suboptimal management decisions.

Isola delle Femmine, also known as “Isola di Fuori” (38°12′37.2″N, 13°14′13.1″E), is located in the Tyrrhenian Sea in northwest Sicily (Italy), near Palermo, along a stretch of coast between Capo Gallo and Punta Raisi, in the Gulf of Carini. A 2-meter-deep and 400-meter-long arm of sea separates the island from the mainland. The Isola delle Femmine Nature Reserve was established in 1997 by the Sicilian Region and managed by Lipu. The island is included in the Nature 2000 network and is recognized as a Special Area of Conservation (SAC ITA020005) protected under the EU Habitats and Birds Directive. For a detailed description of this biotope, see Caldarella et al. (2010), Sparacio et al. (2021), and Viviano et al. (2021).

Since the beginning of the management, Lipu has driven the increase in scientific knowledge of the island. Many papers have been published on geology, botany, and zoology. Some strategic action on invasive species such as grey rat (*Rattus norvegicus* Berkenhout, 1769), wild rabbit (*Oryctolagus cuniculus* Linnaeus, 1758), prickly pear cactus (*Opuntia* sp.), Pome of Sodom (*Solanum lin-*

neaunum Hepper & P.-M.L. Jaeger), were successfully completed.

In this context, being a small island, promoting, restoring, and conserving wildlife, ecosystem services, and more is essential, as well as general biodiversity. In fact, it is reported that diversification and conservation strategies should be implemented to promote habitat diversity at small scales, even in regions with more than 80% of (semi-) natural habitats (Zanini et al., 2024).

The bee hotel serves generally to a dual purpose. First, it provides a place for native bees to lay eggs during the warm season and serves as their home during pollination. Second, it gives the bees a place to overwinter when the seasons change (González-Zamora et al., 2021). Unlike hotels, they are not used for short overnight or week-long stays. Instead, they should provide long-term accommodation where a bee lives and lays an egg until it emerges as a fully grown adult.

In our project, the solitary bee hotels also served other purposes: firstly, they are kept and restored during the winter season to help wild bees during overwintering, and second, to increase curiosity and knowledge in the general public regarding wild pollinators and their importance in a natural environment but also in agriculture, in fact, the Nature Reserve is visited every summer by more than thousand tourists.

A recent study (Leto et al., 2024) shows that middle school students have a good knowledge concerning the importance of bees, but some lack the biology and ecology of these insects. This lack of knowledge was mainly associated with the lack of time spent outdoors living in the city. It is also interesting that students who say they spend less time outdoors feel more afraid of bees, highlighting how the lack of contact with nature alters their perception. A study also showed that a social media campaigns can significantly stimulate citizen science participation (Shilubane et al., 2024). We believe that solitary bee hotels located on Isola delle Femmine can also increase the curiosity and awareness of students and the general public regarding wild bees.

MATERIAL AND METHODS

Study area

The primary purpose of installing the nesting site

in a nature reserve was to renaturalize the island ecosystem by the reserve manager, encourage the reproduction of endemic flora, and attract the attention of tourists, helping them understand the importance of pollinators. The Isola delle Femmine Nature Reserve spans approximately 14 hectares and has an oval shape (Fig. 1). Bee hotels were strategically placed next to a watering hole on the island's east side. The choice of location was made considering the general characteristics of the island; in particular, this side is rich in *Pistacia lentiscus* L., a Mediter-

anean evergreen shrub that, with its bushy shape, provides wind protection and reduces the impact of marine aerosol. The location is also along the primary path of the reserve, which is meant to meet the more significant number of visitors.

Construction of bee hotels

A prototype of a bee hotel (Figs. 2, 3) was installed in 2015 at Isola delle Femmine Nature Reserve. Unfortunately, the structure could not



Figure 1. Isola delle Femmine Nature Reserve, northwest of Sicily, near Palermo (Italy). Photo taken from the airplane by Captain Luca Lazzara in August 2008. Figure 2. A prototype installed in 2015; the image was taken during spring 2016. Figure 3. Colonized prototype reeds.

withstand the climatic factors of the island; therefore, two new bee hotels (38°12'37.2"N, 13°14'13.1"E) were built in May 2016 and installed in July 2016. The materials of the bee hotels were chosen based on their resistance to climatic factors such as wind, rain, and saltiness. All materials used were exclusively recycled and, therefore, at no cost.

Giant reeds, *Arundo donax* L., were used and gathered near the small seaside city of Isola delle Femmine (province of Palermo) to allow pollinators to nest. Later, the giant reeds were sun-dried for over a week and cleaned, removing all the leaves and leaving only the culm part. Subsequently, each reeds were cut (length \pm 16 cm), and the internodes were drilled to create uninterrupted tunnels for nesting (length \pm 10 cm; diameters from 5 mm to 1.5 cm).

Metal food cans with bisphenol A-free enamel were utilized to lock reeds securely. In order to protect the reeds from salt exposure, cans were further recoated with a non-toxic anti-rust enamel. Once dried, the reeds were packed inside the cans, with approximately 650 reeds per hotel.

All wooden materials used for the hotel's construction were recycled from pallets and fruit boxes. Therefore, wooden boards were cut, painted, and assembled to form a square base (15 cm diameter x 48 cm length). The bottom boards were spaced slightly (\pm 1.5 cm) to provide additional entry points for pollinators. Once the two bee hotel bases were constructed, sloping roofs were built as the main barrier against rainwater. The entire structure was then painted with a mahogany-colored wood stain, typically used for boat varnishing.

Finally, metal clamps securely attached the bee hotels to a chestnut wooden pole, painted with the same protective stain, and installed into the ground approximately 15 m from each other.

Installation of wild bee hotels

Solitary wild bees travel a maximum distance of 550 meters from their nesting site to forage for pollen and nectar (Falk, 2019). Therefore, food needs to be within easy flying distance of their nest. Wild bee hotels were placed in a sunny spot, protected from high winds, and surrounded by pollinator-friendly wildflowers generally belonging to the Asteraceae, Brassicaceae, Euphorbiaceae, and Malvaceae families. Bee hotels were installed during the spring to prepare for the first generation of solitary

bees emerging and searching for homes. In addition, two years after installations, a wire mesh was added in each bee hotel to prevent the wind from pushing out reeds from the structure and to prevent vandalism actions that may damage the reeds.

Monitoring of bee hotels

Over the last 30 years, an increasing number of scientific articles have been published on the ecology and conservation of wild bees. To achieve research goals, many studies have pursued a way of capturing wild bees that sometimes turns lethal. Although such deadly impact for scientific pursuits is likely negligible compared to the negative impacts of human phenomena such as climate change, urbanization, and agricultural intensification, in our study we minimize the potential impact of sampling reducing the captured or killed specimens to few individuals.

RESULTS

Trap-nest occupancy

In less than 1 one month, almost all bee tubes, as evidenced by caps of resin, sand, plant material, or leaves, were collected during the 2015/16/17 survey season. Monitoring and restoring the tubes was done every spring and, when necessary, until now. The occupancy rate was very high, more than 95% reaching 100%.

The two bee hotels proved to be resilient to the exposition of atmospheric agents in the long term, without reporting any damage, and represent excellent nesting sites for local pollinators. Indeed, on both sides, the totality of reeds was filled with wax, propolis, pollen, and mud cell walls (Figs. 4–8). Individuals belonging to different species of the Megachilidae family have been observed nesting in the bee hotels (Fig. 9). This demonstrates that such structures provide favorable conditions that help wild pollinators to reproduce. Furthermore, closed stem “cells” of nesting tubes in autumn were observed, showing that new bees will hatch in the spring. Moreover, they made hotels serve as winter habitats.

In addition, predators, such as parasitic wasps and specimens of Heteroptera belonging to the Anthocoridae family, which feed on wild bee eggs, and parasitoids of the family Meloidae have been ob-



Figure 4. Reeds packed and locked inside the metal cans. Figure 5. The wooden structure of the bee hotels after painting with a mahogany-colored wood stain. Figure 6. The first bee hotel constructed and installed on the islet in 2016. Figure 7. The second bee hotel installed. Figure 8. Colonized reed cut in half longitudinally filled with wax, propolis, pollen, and mud cell walls.



Figure 9. Megachilidae specimens found nesting in the bee hotels after one year.

served (Fig. 10). Moreover, tiny arachnids that inhabit bee hotels, that probably act as kleptoparasites (food or brood thief). These mites, known as pollen mites, probably belonging to *Chaetodactylus* spp., have a wide distribution range, being found across North America and Europe; they can be pests of Megachilid solitary bees (Vicidomini, 1999; Klimov & OConnor, 2004). Furthermore, visitors to the islet showed interest and curiosity toward the two bee hotels, asking questions regarding hotel bees, and in general pollinators and pollination. In this way, the visitor is delivered with a plethora of information, including the importance of conserving wild pollinators. The person here receives this information simultaneously via multiple senses and situations. According to Moon & Han (2019), a variety of information derived from the visit and en-

vironment, even on a small island, made the person an active participant and promoted sensibility to the environment and consequently to fauna protection.

However, it is crucial to notice that not all authors agree whether the placement of bee hotels have empirical evidence of their positive impact on pollinator biodiversity, as they benefit only a small proportion of common and widespread species; so the role of bee hotels remains to be explored (MacIvor & Packer, 2015; Drossart & Gérard, 2020). On the contrary, the role of bee hotels is widely recognized in establishing a citizen science initiative that would aid in the development of a society of environmentally and socially conscious citizens capable of advocating for environmental justice (Shilubane et al., 2024).

CONCLUSIONS

Small conservation areas are disproportionately crucial to maintaining biodiversity. The main aim of the regional government in establishing small nature reserves is to develop small protected areas to test innovative ways of managing them and extend them to large and complex ecosystems.

The results of this study show that bee hotels are effective in attracting a good presence of pollinators. This highlights the need for further investigations to identify the species present and in which proportion they are present with each other so that we can link the presence of wild bees with botanical diversity.

In conclusion, the exposition of the two nesting sites to the audience has represented an opportunity to make a disclosure activity that promotes the importance of wild pollinators and increases environmental protection awareness among people.

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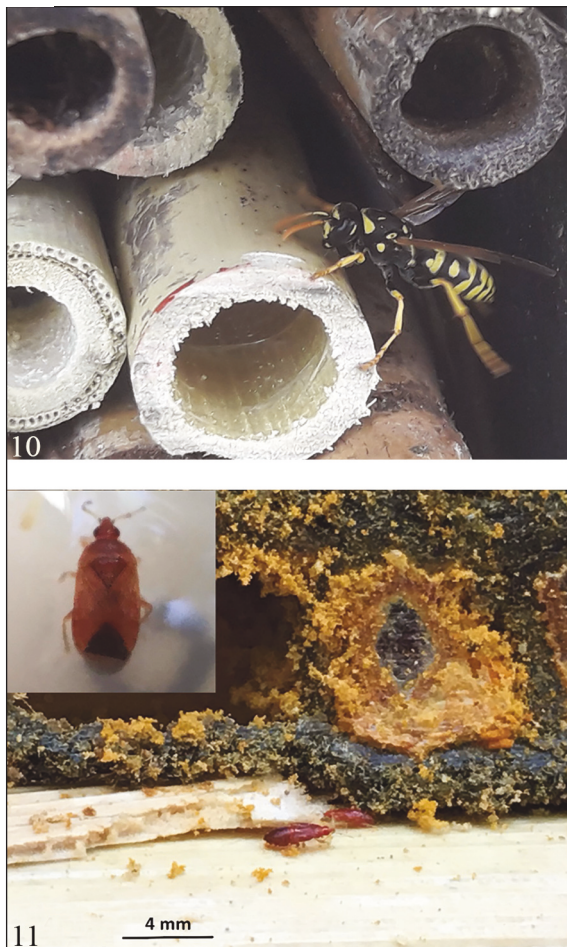


Figure 10. Predatory wasp observed in 2017. Figure 11. Specimens of Heteroptera Anthocoridae. The image above on the right shows a close-up of the individual.

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