Italian wild bees biodiversity and Vesuvius National Park

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Abstract
Wild insect pollinators belonging to the superfamily Apoidea are essential for the seed production of flowering plants worldwide. Nevertheless, their global populations have experienced significant declines, with serious negative implications for insect-pollinated plants. Nevertheless, there is limited knowledge available regarding this group of insects, especially in natural parks. Here we wanted to fill the gap by studying the prevalence of Apoidea species in Vesuvius National Park area. We have found a total of 176 species, representing a large part of biodiversity of Italian wild bees.

Key words: checklist, wild bees, Apoidea, pollinators, DNA barcoding, ecosystem services.

First submission: 6 August 2024; *accepted*: 5 September 2024

1. Introduction

In recent decades, global populations of bees and other insect pollinators have experienced significant declines, with serious negative implications for

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Rivista di Studi sulla Sostenibilità, (ISSN 2239-1959, ISSNe 2239-7221), 2024, 2

Doi: 10.3280/RISS2024-002008

insect-pollinated crop yields (Walton et al., 2020). These declines are attributed to the destruction of nesting habitats and foraging sites (Hausmann et al., 2015), having increasing attention in political debates and public opinion (Walton et al., 2020). Pollinators are essential for the seed production of flowering plants worldwide (Ollerton et al., 2011), being fundamental for ecosystem services assurance, underscoring the importance of studying the biodiversity of wild bees in the Vesuvius National Park (VNP) through a specific checklist. The main contributions referring to the Apoidea superfamily can be found in the works of Priore (1977, 1979-85, 1989, 1991), Priore et al. (1998), other significant works are made by Vicidomini (2000a and 2000b), Vicidomini and Pignataro (2007), Pagliano (1987) and Pagliano and Scaramozzino (1999). The latest update regarding Apoidea superfamily was from Comba (2007), where 97 species of bees were reported. Nevertheless, there is limited information available regarding the Hymenoptera fauna of VNP, and, more broadly, in the Campania region and much of the existing information is often outdated. Here we aimed to fill the gap with an in depth-study of prevalence of Apoidea species in VNP and neighboring areas.

2. Materials and methods

The VNP extends in approximately 8.5 hectares, encompassing the territories of 13 municipalities. Here we have identified 10 hot-spots characterized by diverse biocenoses as sampling points (VNP001-VNP010). Out of these, 5 were situated in natural or minimally impacted environments, while the remaining 5 were located within agricultural areas (Fig. 1, Tab. 1). Moreover, locations related to referenced samples were also indicated (VNP011-VNP014) (Tab. 2).

Table 1 – List of locations where samples were collected

Cod.	Place	Altitude (m/a.s.l.)	Type of Hotspot
VNP001	Trecase (NA)	224	agricultural
VNP002	Ercolano (NA)	545	natural
VNP003	Ercolano (NA)	266	agricultural
VNP004	Sant'Anastasia (NA)	393	natural
VNP005	Ercolano (NA)	507	natural
VNP006	Ottaviano (NA)	544	agricultural
VNP007	Boscotrecase (NA)	194	agricultural
VNP008	Ercolano (NA)	978	natural
VNP009	Boscotrecase (NA)	354	natural
VNP010	Ercolano (NA)	184	agricultural

Table 2 – List of locations of species taken from literature

Cod.	Place	Reference
VNP011	Portici (NA)	Priore, 1982
VNP012	Ercolano (NA)	Comba, 2007
VNP013	Torre del Greco (NA)	Priore, 1982
VNP014	Somma Vesuviana (NA)	Priore, 1979

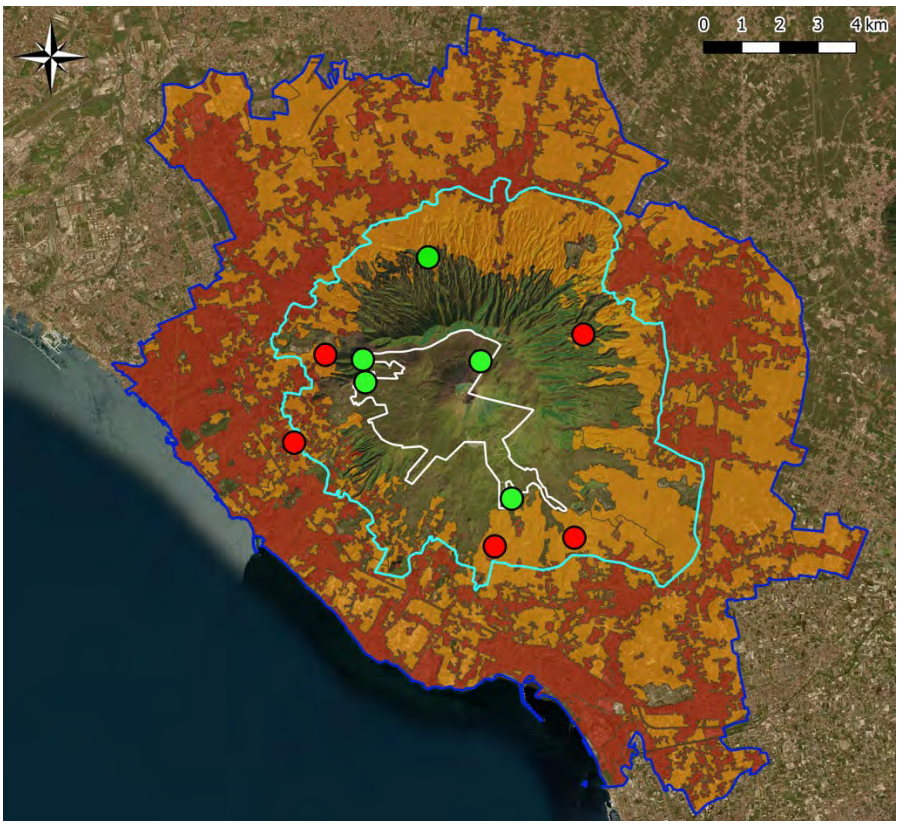
In each hotspot were collected Apoidea species, twice a month, from February to October, in 2022 and 2023. The sampling method was the fixed transect of 250 x 4 m (Westphal et al., 2008), a permanent vegetated corridor along which specimens were identified and/or collected and counted during a 50-minute walk. Specimens were thorax-pinned under a stereomicroscope using entomological pins. For the purposes of recognition and subsequent identification from each insect, the mouthparts of both sexes were opened, and the genital apparatus were extracted to be clearly visible. The Italian distribution of the species was taken mostly from Ruffo and Stoch (2005).

The hindleg of all specimens were isolated and stored at -20°C for the subsequent molecular analysis, that was carried out on 30 random sampling using the DNA Barcoding approach involving the amplification of the COI gene. DNA extraction was performed by using Chelex resin protocol while the DNA amplification involved standard primers (LCO1490, F5'-GGTCAACAAATCATAAAGATATTGG-3' and HCO2198, R5'-TAAACTTCAGGGTGACCAAAAAATCA-3') as described by Folmer *et al*. 1994. Polymerase chain reaction (PCR) amplification was carried out using 50 µl of PCR master mix with 5 µl of 10X Taq buffer, 3 µl of 1.5 mM $MgCl_2$, 2 µl of 5 mM dNTP, 2.5 µl of 10 µM of each primer, 1.25U Taq DNA Polymerase recombinant (Thermo Fisher Scientific) and 1 µl of genomic DNA. The thermal cycling parameters of PCR included an initial denaturation at 94°C for 1 min, followed by 40 cycles of denaturation at 94°C for 30 sec, annealing at 48°C for 120 sec, and extension at 72°C for 60 sec. One cycle of a final extension for 7 min at 72°C was also performed. PCR amplification was checked on a 1% agarose gel. Raw sequences were obtained by using Sanger analysis while the species identification was performed with comparison to the available data on gene bank (Hajibabei et al., 2006; Ratnasingham et al., 2007).

The map of the sites was created using QGIS v3.28.3. The shapefile layers were courtesy provided by the VNP administration, while the Digital Elevation Model utilized with a resolution of 10 m was provided by the National Institute of Geophysics and Volcanology (INGV) in Pisa, Italy (Tarquini et al., 2023). The shapefile layers of the VNP boundaries were kindly

provided by the Vesuvius National Park Institution, while the agricultural and the urban areas were provided by ISPRA (Bagnaia et al., 2017)

Figure 1 – Hotspots for insect sampling in VNP. Agricultural landscape (red dots) and natural landscape (green dots). Solid lines indicate Integral Natural Reserve (white), Man and the Biosphere Programme area (MAB), (light blue) and relative MAB buffer zone (dark blue). Agricultural landscape (orange) is composed of five different classes including vineyards, orchards, citrus groves, extensive and intensive agriculture, while urban landscape (dark red) includes urban fabric and production and commercial sites



3. Results

The annotated check list of species collected in the VNP during 2022 and 2023 is indicated in the table (Tab. 3), following the standard indications reported by Ghisbain et al., 2023. All the species indicate both sex (♂ and

♀), locations where species were found and the Italian distribution. Moreover, the species reported in the literature and species with missing data are also indicated with "*" and "?", respectively. Species analyzed molecularly are indicated with "**", where the results confirm the morphological identification. Total species of Apoidea collected from the entomological expeditions was 137, to which it has added 39 species collected in the past by other entomologists, up to a total of 176 *taxa*.

Table 3 – Species of wild Bees collected in VNP during 2022 and 2023. The table reported the name of species, place, sampling data, number and sex and distribution (N, north; C centre: S, south; Sa, Sardinia Island; Si, Sicily Island. Samples reported in the literature (*), species analyzed molecularly (**) and species with missing data (?) are also indicated

Specie	Place	Sampling data	Samples	Distribution
Andrena aeneiventris Morawitz, 1872	VNP001	V; VI	2 ♀	N; C; S; Si
Andrena cinerea Brullé, 1832	VNP002 VNP003	V; VI	1♂; 7 ♀	N; C; S; Sa; Si
Andrena senecionis Pérez, 1895	VNP004 VNP005	V	5 ♀	N; C; S; Si
**Andrena stabiana* Morice, 1889	VNP012	V	1 ♀	N; C; S; Sa; Si
Andrena hesperia Smith, 1853	VNP001 VNP002 VNP005 VNP008	IV; V; VI	12 ♂; 5 ♀	N; C; S; Sa; Si
Andrena bicolor Fabricius, 1775	VNP005	V	1 ♀	N; C; S; Sa; Si
**Andrena vulpecula* Kriechbaumer, 1873	VNP011	V	?	N; C; S; Sa; Si
Andrena pellucens Pérez, 1895	VNP006 VNP007 VNP010	X	3 ♀	N; C; Si
**Andrena fuscosa* Erichson, 1835	VNP011 VNP013	III	?	N; C; S; Si
**Andrena discors* Erichson, 1841	VNP011	?	?	N; C; S
Andrena flavipes Panzer, 1799	VNP005 VNP008	IV; V	1♂; 2 ♀	N; C; S; Si; Sa
***Andrena nigroaenea* (Kirby, 1802)	VNP002 VNP007 VNP010	IV; V; VI	2 ♂; 1 ♀	N; C; S; Sa; Si
Andrena thoracica (Fabricius, 1775)	VNP006	VII	1 ♂	N; C; S; Sa; Si
Andrena minutula (Kirby, 1802)	VNP002 VNP007 VNP008 VNP010	IV; V; VI	1 ♂; 3 ♀	N; C; S; Sa; Si
Andrena minutuloides Perkins, 1914	VNP010	V	1 ♂	N; C; S; Sa
Andrena agilissima (Scopoli, 1770)	VNP007	VII	1 ♀	N; C; S; Sa; Si
Andrena bimaculata (Kirby, 1802)	VNP003	V	1 ♂	N; C; S; Sa; Si
Andrena pilipes Fabricius, 1781	VNP007	IV; VII	2 ♀	N; C; S; Sa; Si

Specie	Place	Sampling data	Samples	Distribution
Andrena combinata (Christ, 1791)	VNP007 VNP010	IV; V	1 ♂; 5 ♀	N; C; S; Sa; Si
Andrena afzeliella (Kirby, 1802)	VNP004 VNP005 VNP006 VNP007 VNP009	V; VI	5 ♂; 3 ♀	N; C; Sa
Andrena croceiventris Morawitz, 1871	VNP006	VI	1 ♂; 1 ♀	N; C; S
**Andrena ovatula* (Kirby, 1802)	VNP011	IV	?	N; C; S; Sa; Si
Andrena russula Lepeletier, 1841	VNP002 VNP005	IV, V	3 ♂	N; C; S; Sa
**Andrena wilkella* (Kirby, 1802)	VNP011	IV	?	N; C; S; Si
**Andrena schmiedeknechti* Magretti, 1883	VNP011	IV	?	N; C; S; Si
**Andrena fulvitarsis* Brullé, 1832	VNP011	?	?	N; C; S; Si
**Panurgus canescens* Latreille, 1811	VNP011	?	?	N; C; S; Sa; Si
Panurgus calcaratus (Scopoli, 1763)	VNP001 VNP003 VNP004 VNP005 VNP007 VNP009	V; VI; VII	7 ♂; 2 ♀	N; C; S; Sa; Si
**Ammobates punctatus* (Fabricius, 1804)	VNP011	?	?	N; C; S
**Amegilla garrula* Warncke, 1965	VNP011	?	?	N; C; S; Sa; Si
**Amegilla quadrifasciata* (de Villers, 1789)	VNP011	?	?	N; C; S; Sa; Si
**Amegilla albigena* (Lepeletier, 1841)	VNP011	?	?	N; C; S; Sa; Si
**Amegilla savignyi* (Lepeletier, 1841)	VNP011	?	?	N; C; S; Sa; Si
Anthophora crinipes Smith, 1854	VNP009 VNP010	IV; V	4 ♂; 1 ♀	N; C; S; Sa; Si
Anthophora plumipes (Pallas, 1772)	VNP002 VNP003 VNP004 VNP005 VNP010	IV; V	4 ♂; 5 ♀	N; C; S; Sa; Si
Anthophora bimaculata (Panzer, 1798)	VNP003	VII	4 ♂	N; C; S; Si
Anthophora dispar Lepeletier, 1841	VNP008 VNP009	III; IV; V	1 ♂; 2 ♀	N; C; S; Sa; Si
**Anthophora mucida* Gribodo, 1873	VNP011	II	?	N; C; S; Si
**Anthophora aestivalis* (Panzer, 1801)	VNP011	?	?	N; C; S; Si
Anthophora retusa (Linnaeus, 1758)	VNP002 VNP004 VNP005 VNP006 VNP009	IV; V; VI	8 ♂; 1 ♀	N; C; S; Sa; Si
Habropoda tarsata (Spinola, 1838)	VNP004	IV	2 ♀	N; C; S; Si
Apis mellifera Linnaeus, 1758	VNP001 VNP014	V; VII	?	N; C; S; Sa; Si
***Bombus terrestris* (Linnaeus, 1758)	VNP002 VNP003 VNP005 VNP008 VNP009	III; IV; VI; VII; VIII; IX;	3 ♂; 8 ♀	N; C; S; Sa; Si
Bombus pratorum (Linnaeus, 1761)	VNP008	V	1 ♀	N; C; S; Si
Bombus hortorum (Linnaeus, 1761)	VNP003	VII	2 ♂	N; C; S; Sa

Specie	Place	Sampling data	Samples	Distribution
**Bombus ruderatus* (Fabricius, 1775)	VNP011	V	?	N; C; S; Si
**Bombus humilis* Illiger, 1806	VNP011	V	?	N; C; S; Si
***Bombus pascuorum* (Scopoli, 1763)	VNP001 VNP002 VNP003 VNP004 VNP005 VNP006 VNP008 VNP010	IV; V; VI; VII; VIII; X	2 ♂; 54 ♀	N; C; S; Si
**Bombus sylvarum* (Linnaeus, 1761)	VNP011	XI	?	N; C; S; Si
***Ceratina cucurbitina* (Rossi, 1792)	VNP001 VNP002 VNP003 VNP004 VNP005 VNP006 VNP008 VNP010	IV; V; VII; IX; X	26 ♂; 15 ♀	N; C; S; Sa; Si
Ceratina parvula Smith, 1854	VNP001 VNP002 VNP005 VNP009 VNP010	IV; V; VI; VII; VIII	1 ♂; 31 ♀	N; C; S; Sa; Si
Ceratina chalcites Germar, 1839	VNP002 VNP003 VNP008 VNP009	V; VI; VII; VIII; IX	1 ♂; 9 ♀	N; C; S; Si
Ceratina chalybea Chevrier, 1872	VNP004 VNP005 VNP008	V; VII; VIII; IX	6 ♀	N; C; S; Sa; Si
***Ceratina cyanea* (Kirby, 1802)	VNP002 VNP003 VNP004 VNP008 VNP010	V; VI; VII; VIII; IX; X	5 ♂, 11 ♀	N; C; S; Sa; Si
Ceratina dallatorreana Friese, 1896	VNP001 VNP003 VNP007 VNP009	V; .VI; VII; VIII; IX	3 ♂; 5 ♀	N; C; S; Sa; Si
Ceratina dentiventris Gerstaecker, 1869	VNP009	VIII	1 ♀	N; C; S; Sa; Si
Ceratina gravidula Gerstaecker, 1869	VNP002	VIII	2 ♂	N; C; S; Si
Epeolus cruciger (Panzer, 1799)	VNP003	VII	2 ♂	N; C; S
**Eucera caspica* Morawitz, 1873	VNP011	IV	?	N; C; S; Si
***Eucera nigrescens* Pérez, 1879	VNP002 VNP007 VNP009	IV; V	2 ♂, 3 ♀	N; C; S; Sa; Si
**Eucera nigrifacies* Lepeletier, 1841	VNP011	?	?	N; C; S; Sa; Si
**Tetralonia dentata* (Germar, 1839)	VNP011	?	?	N; C; S; Sa; Si
Tetralonia malvae (Rossi, 1790)	VNP003 VNP010	VI; VII	2 ♂	N; C; S; Sa; Si
Melecta albifrons (Forster, 1771)	VNP002	VII	1 ♀	N; C; S; Sa; Si
**Melecta italica* Radoszkowski, 1876	VNP011	?	?	N; C; S; Sa; Si
Melecta luctuosa (Scopoli, 1770)	VNP002 VNP005 VNP006	IV; V	12 ♂	N; C; S; Sa; Si
**Thyreus ramosus* (Lepeletier, 1841)	VNP011	?	?	N; C; S; Sa; Si
Nomada argentata Herrich-Schäffer, 1839	VNP007	IX	1 ♂	N; C; Si
Nomada carnifex Mocsáry, 1883	VNP002	IV	2 ♂	N; S; Si
Nomada flavoguttata (Kirby, 1802)	VNP005	IV	2 ♂	N; C; S; Si

Specie	Place	Sampling data	Samples	Distribution
Xylocopa iris (Christ, 1791)	VNP001 VNP008 VNP009	VIII; X	3 ♀	N; C; S; Sa; Si
Xylocopa valga Gerstaecker, 1872	VNP003	VII	1 ♂	N; C; S; Si
***Xylocopa violacea* Linnaeus, 1758	VNP003 VNP009	IV; VI; IX	1 ♂; 4 ♀	N; C; S; Sa; Si
**Colletes dimidiatus* Brullé, 1840	VNP011	?	?	N; C; S; Sa; Si
Colletes fodiens (Fourcroy, 1785)	VNP009	V; VI	3 ♂; 1 ♀	N; C; S
Colletes hederae Schmidt and Westrich, 1993	VNP004	X	1 ♀	N; C; Si
Colletes similis Schenck, 1853	VNP009	V; X	2 ♂	N; C; S; Sa; Si
**Colletes succinctus* (Linnaeus, 1758)	VNP011	?	?	N; C; S; Sa; Si
Hylaeus brevicornis Nylander, 1852	VNP005 VNP008 VNP009 VNP010	V; IX; X	1 ♂; 3 ♀	N; C; S; Sa; Si
Hylaeus imparilis Förster, 1871	VNP001 VNP010	VIII; IX	4 ♀	N; C; S; Sa; Si
Hylaeus communis Nylander, 1852	VNP001 VNP002 VNP008	IV; V; VII; IX	1 ♂; 4 ♀	N; C; S; Sa; Si
**Hylaeus tyrolensis* Förster, 1871	VNP011	VI	?	N; C; S
**Hylaeus variegatus* (Fabricius, 1798)	VNP011	?	?	N; C; S; Sa; Si
Hylaeus clypearis (Schenck, 1853)	VNP004 VNP005 VNP007 VNP009 VNP010	V; VIII; IX	9 ♂; 2 ♀	N; C; S; Sa; Si
***Hylaeus taeniolatus* Förster, 1871	VNP007	V	1 ♀	N; C; S; Si
**Hylaeus gibbus* Saunders, 1850	VNP011	VII	?	N; C; S; Sa; Si
**Hylaeus signatus* (Panzer, 1798)	VNP011	V; VI	?	N; C; S; Sa
***Hylaeus punctatus* (Brullé, 1832)	VNP002 VNP003 VNP010	V; VII; VIII; IX	6 ♂; 4 ♀	N; C; S; Sa; Si
Halictus patellatus Morawitz, 1874	VNP003	VI	1 ♂; 1 ♀	N; C; S; Sa; Si
Halictus quadricinctus (Fabricius, 1776)	VNP001 VNP002 VNP003 VNP007 VNP008 VNP010	IV; V; VI; VII	5 ♂; 8 ♀	N; C; S; Sa; Si
Halictus fulvipes (Klug, 1817)	VNP001 VNP003 VNP004 VNP007 VNP008 VNP009 VNP010	V; VI; VII; VIII; IX	6 ♂; 23 ♀	N; C; S; Sa; Si
***Halictus scabiosae* (Rossi, 1790)	VNP002 VNP003 VNP005 VNP007 VNP008	IV; VII; VIII	1 ♂; 6 ♀	N; C; S; Sa; Si
Halictus asperulus Pérez, 1895	VNP005 VNP006 VNP008	IV; VII	1 ♂; 9 ♀	N; C; S; Si
Halictus maculatus Smith, 1848	VNP002	VII	1 ♀	N; C; S; Sa; Si

Specie	Place	Sampling data	Samples	Distribution
Lasioglossum aeratum (Kirby, 1802)	VNP008	V; VI	2 ♂; 1 ♀	N; C; S; Sa; Si
***Lasioglossum morio* (Fabricius, 1793)	VNP004 VNP005 VNP008 VNP010	V; VI; VIII; IX	2 ♂; 9 ♀	N; C; S; Si
Lasioglossum nitidulum (Fabricius, 1804)	VNP010	VI; VII; VIII; IX;	3 ♂; 4 ♀	N; C; S; Sa; Si
***Lasioglossum brevicorne* (Schenck, 1868)	VNP002 VNP003 VNP004 VNP005 VNP007 VNP008	IV; V; VI; VII; VIII	5 ♂; 27 ♀	N; C; S; Sa; Si
Lasioglossum elegans (Lepeletier, 1841)	VNP007	V; VII	2 ♀	N; C; S; Si
Lasioglossum griseolum (Morawitz, 1873)	VNP001 VNP002 VNP003 VNP004 VNP006 VNP008	V; VI; VII; VIII	2 ♂; 7 ♀	N; C; S; Sa; Si
***Lasioglossum limbellum* (Morawitz, 1876)	VNP002 VNP004 VNP007 VNP010	IV; V; VII; VIII; IX	1 ♂; 6 ♀	N; C; S; Sa; Si
***Lasioglossum punctatissimum* (Schenck, 1853)	VNP004 VNP005 VNP008	IV; V; VI	4 ♀	N; C; S; Si
**Lasioglossum sexstrigatum* (Schenck, 1870)	VNP013	?	?	N; C; S
Lasioglossum transitorium (Schenck, 1868)	VNP001 VNP002 VNP003 VNP005 VNP007 VNP009 VNP010	IV; V; VI; VII; VIII	?	N; C; S; Sa; Si
Lasioglossum villosulum (Kirby, 1802)	VNP005	X	1 ♀	N; C; S; Sa; Si
Lasioglossum bimaculatum (Dours, 1872)	VNP010	V	1 ♀	N; C; S; Sa; Si
Lasioglossum laterale (Brullé, 1832)	VNP008	VI	6 ♀	N; C; S; Si
***Lasioglossum lativentre* (Schenck, 1853)	VNP005 VNP007	V; VI	6 ♀	N; C; S; Sa; Si
**Lasioglossum sexnotatum* (Kirby, 1802)	VNP011	?	?	N; C; S; Sa; Si
Lasioglossum leucozonium (Schrank, 1781)	VNP002 VNP003 VNP004 VNP006 VNP008	V; VI; VII; VIII	1 ♂; 15 ♀	N; C; S; Sa; Si
Lasioglossum politum (Schenck, 1853)	VNP003 VNP006 VNP007 VNP010	IV; V; VI; VII; IX	14 ♀	N; C; S; Si
***Lasioglossum interruptum* (Panzer, 1798)	VNP003 VNP004 VNP006 VNP007 VNP010	IV; V; VI	1 ♂; 4 ♀	N; C; S; Sa; Si
Lasioglossum laticeps (Schenck, 1868)	VNP002 VNP004 VNP007 VNP008	IV; V; VII	4 ♀	N; C; S; Si
***Lasioglossum malachurum* (Kirby, 1802)	VNP003 VNP007 VNP010	VI; VII; X	3 ♀	N; C; S; Sa; Si
Lasioglossum nigripes (Lepeletier, 1841)	VNP002 VNP005 VNP007	V; VII; IX; X	7 ♀	N; C; S; Sa; Si
Lasioglossum pauxillum (Schenck, 1853)	VNP008	VII	1 ♂	N; C; S; Sa; Si
***Lasioglossum tricinctum* (Schenck, 1874)	VNP006 VNP009	IV; VI; VII	4 ♂; 7 ♀	N; C; S; Si

Specie	Place	Sampling data	Samples	Distribution
Seladonia smaragdula (Vachal, 1895)	VNP001 VNP002 VNP003 VNP005 VNP007 VNP010	V; VI; VII; VIII; IX	13 ♂; 21 ♀	N; C; S; Sa; Si
**Seladonia subaurata* (Rossi, 1792)	VNP003 VNP005	V; VI; VII	4 ♀	N; C; S; Sa; Si
**Seladonia pulverea* (Morawitz, 1873)	VNP011	VII	?	N; S
Seladonia vestita (Lepeletier, 1841)	VNP001 VNP002 VNP003 VNP007 VNP010	VI; VII	12 ♀	N; C; S; Sa; Si
***Sphecodes albilabris* (Fabricius, 1793)	VNP003	VI	1 ♀	N; C; S; Sa; Si
**Sphecodes gibbus* (Linnaeus, 1758)	VNP011 VNP014	VI; VII	?	N; C; S; Sa; Si
**Sphecodes monilicornis* (Kirby, 1802)	VNP011 VNP013	V; VI	?	N; C; S; Sa; Si
Ceylalictus variegatus (Oliver, 1789)	VNP003 VNP010	V; IX	1 ♂; 1 ♀	N; C; S; Sa; Si
Nomioides facilis (Smith, 1853)	VNP003 VNP004 VNP005 VNP007 VNP010	V; VI; VII; VIII; IX	21 ♂; 46 ♀	N; C; S; Si
***Anthidiellum strigatum* (Panzer, 1805)	VNP003 VNP009	VIII	3 ♂; 1 ♀	N; C; S; Sa; Si
***Anthidium manicatum* (Linnaeus, 1758)	VNP003	VIII	1 ♂	N; C; S; Sa; Si
Icteranthidium grohmanni (Spinola, 1838)	VNP009	VIII	1 ♂; 2 ♀	N; C; S; Si
Pseudoanthidium nanum (Mocsáry, 1880)	VNP001 VNP003 VNP009	VI; VII; VIII	1 ♂; 5 ♀	N; C; Sa; Si
**Pseudoanthidium melanurum (Klug, 1832)	VNP008 VNP009 VNP010	VI; VII	3 ♂; 4 ♀	C; S; Sa; Si
Rhodanthidium septemdentatum (Latreille, 1809)	VNP003 VNP004 VNP005 VNP007 VNP010	V; VI; VII	5 ♂; 5 ♀	N; C; S; Si
Stelis signata (Latreille, 1809)	VNP009	VIII	1 ♂; 1 ♀	N; C; S; Si
Stelis phaeoptera (Kirby, 1802)	VNP009	VI	1 ♂	N; C; S; Sa; Si
Trachusa interrupta (Fabricius, 1781)	VNP003	VII	2 ♂	N; C; S; Sa; Si
*Megachile (Chalicodoma) apennina Benoist, 1940	VNP011	IV; VI	?	C; S
Megachile parietina (Geoffroy, 1785)	VNP002 VNP004 VNP008 VNP009	IV; VI; VII, VIII	5 ♂; 6 ♀	N; C; S; Sa; Si
Megachile argentata (Fabricius, 1793)	VNP005 VNP009	V; VI	3 ♀	N; C; S; Sa; Si
Megachile apicalis Spinola, 1808	VNP005 VNP009 VNP010	VI; VII; VIII; IX	2 ♂; 5 ♀	N; C; S; Sa; Si
Megachile flabellipes Pérez, 1895	VNP008	VI	1 ♂; 2 ♀	N; C; S
Megachile leachella Curtis, 1828	VNP007 VNP008 VNP009	VII; VIII	3 ♂; 3 ♀	N; C; S; Sa; Si

Specie	Place	Sampling data	Samples	Distribution
Megachile centuncularis (Linnaeus, 1758)	VNP001 VNP002 VNP004 VNP005 VNP008	V; VII; VIII; IX; X	3 ♂; 4 ♀	N; C; S; Sa; Si
**Megachile melanopyga Costa, 1863	VNP001 VNP002 VNP003 VNP007	VII; VIII; IX	3 ♂; 5 ♀	N; C; S; Sa; Si
Megachile lagopoda (Linnaeus, 1761)	VNP008	VI	2 ♂	N; C; S; Sa; Si
Megachile maritima (Kirby, 1802)	VNP001 VNP003	VII	2 ♂	N; C; S; Si
Megachile willughbiella (Kirby, 1802)	VNP008 VNP009 VNP010	VI; VII	4 ♀	N; C; S
Chelostoma campanularum (Kirby, 1802)	VNP004	VI	1 ♂; 1 ♀	N; C; S; Si
**Heriades crenulata Nylander, 1856	VNP004 VNP005 VNP009	VI; VII; VIII; IX	2 ♂; 10 ♀	N; C; S; Sa; Si
**Heriades rubicola Pérez, 1890	VNP001 VNP009	VII; VIII	3 ♂; 1 ♀	N; C; S; Sa; Si
Hoplitis leucomelana (Kirby, 1802)	VNP003 VNP004 VNP008	V; VI; VII	1 ♂; 4 ♀	N; C; S; Sa; Si
**Hoplitis adunca (Panzer, 1798)	VNP003 VNP008 VNP010	VI	1 ♂; 2 ♀	N; C; S; Sa; Si
Hoplitis anthocopoides (Schenck, 1853)	VNP008	VI	2 ♂	N; C; S; Si
Osmia rufohirta Latreille, 1811	VNP001	IV	1 ♂; 1 ♀	N; C; S; Sa; Si
Osmia aurulenta Panzer, 1799	VNP003	V	1 ♀	N; C; S; Sa; Si
Osmia caerulescens (Linnaeus, 1758)	VNP008	IV; V	1 ♂, 2 ♀	N; C; S; Sa; Si
Osmia dimidiata Morawitz, 1871	VNP003 VNP009	VI; VII	4 ♀	N; C; S; Sa; Si
Osmia latreillei (Spinola, 1806)	VNP001 VNP004 VNP005 VNP007 VNP008 VNP010	IV; V; VII	7 ♂; 9 ♀	N; C; S; Sa; Si
Osmia leaiana (Kirby, 1802)	VNP004 VNP008	V; VI	9 ♂; 1 ♀	N; C; S; Si
Osmia niveata (Fabricius, 1804)	VNP008 VNP009 VNP004	V; VI	2 ♂; 1 ♀	N; C; S; Sa; Si
*Osmia niveocincta Pérez, 1897	VNP012	VI	?	C; S; Sa
Osmia notata (Fabricius, 1804)	VNP002 VNP005 VNP008 VNP009	VI; VII	1 ♂; 7 ♀	N; C; S; Sa; Si
Osmia ligurica Morawitz, 1868	VNP008	VI	1 ♀	N; C; Sa; Si
Osmia scutellaris Morawitz, 1868	VNP002 VNP005 VNP008	V; VI; VIII	6 ♂; 3 ♀	N; C; S
Osmia spinulosa (Kirby, 1802)	VNP001 VNP002 VNP008	IV; V; VI	3 ♂; 4 ♀	N; C; S; Si
Osmia bicornis (Linnaeus, 1758)	VNP005 VNP008	IV; V; VI	6 ♂	N; C; Sa; Si
*Osmia cornuta (Latreille, 1805)	VNP011	?	?	N; C; S; Si
Osmia cephalotes Morawitz, 1870	VNP002 VNP004 VNP005 VNP008	IV; V; VI	2 ♂; 5 ♀	N; C; S; Si
**Osmia gallarum Spinola, 1808	VNP004 VNP005 VNP008	IV; V; VI	6 ♂	N; C; S; Si

Specie	Place	Sampling data	Samples	Distribution
**Osmia submicans Morawitz, 1870	VNP005 VNP009	IV; V; VII	2 ♂; 2 ♀	N; C; S; Sa; Si
Dasypoda hirtipes (Fabricius, 1793)	VNP003 VNP007 VNP008	VI; X	3 ♂; 7 ♀	N; C; S; Sa; Si
Melitta tricincta Kirby, 1802	VNP003 VNP004	IX; X	4 ♂; 1 ♀	N; C; S
Halictus langobardicus Blüthgen, 1944	VNP003 VNP008	VI; VII	2 ♂	N; S; Si
**Bombus lapidarius bisiculus Lecocq, Biella, Martinet & Rasmont, 2019	VNP002 VNP003 VNP004 VNP005 VNP006 VNP008 VNP009	IV; VI; VII; VIII	4 ♂; 18 ♀	N; S; Si
Osmia leucomelana (Kirby 1802)	VNP008	V	1 ♂	N; C; S; Sa; Si
*Coelioxys afer Lepeletier, 1841	VNP011	?	?	N; C; S; Sa; Si
Colletes sp.	VNP007	V	5 ♀	N; C; S; Si

4. Discussion

From the entomological expeditions carried out during 2022-2023 in VPN area, 137 species of Apoidea were caught, to which it has added 39 species collected in the past by other entomologists, up to a total of 176 *taxa*.

Through the fieldwork activities, it was possible to add 98 new species previously unknown to the Vesuvius National Park. The two most representative families are Apidae and Megachilidae; which have 46 and 45 *taxa*, respectively; followed by Halictidae (39), Andrenidae (28), Colletidae (16) and Melittidae (2). *Stelis signata* (Latreille, 1809), *Megachile flabellipes* Pérez, 1895 and *Pseudoanthidium melanurum* (Klug, 1832) (Fig. 2) are reported for the first time in Campania Region. The utilization of updated checklists facilitates our comprehension of the environmental well-being and species richness within the confines of the VNP. Through the implementation of periodic samplings over successive years, we can evaluate fluctuations in the documented species count within the park and act, as necessary, employing the most judicious measures.

Definely, the identified and reported species represent almost 18% of the Italian wild bee biodiversity. This is an important result considering the positive impact of Apoidea pollinators on wild plants, crops, and agro-ecosystem conservation. Surprisingly, the level of Apoidea biodiversity occurs in a relatively small area of 8.5 hectares surrounded by an intense pressure of anthropogenic activities, both city and intensive agricultural lands, leading the VNP area as an island of biodiversity. The unique environment of the

VNP characterized by Mediterranean plants with blooming for 10/12 months is the primary source of food for wild bees that can easily find nesting in the protected areas of the VNP.

Figure 2 – New Apoidea for Campania region: Stelis signata (Latreille, 1809) (A), Megachile flabellipes Pérez, 1895 (B); Pseudoanthidium melanurum (Klug, 1832) (C)

A

B

C

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5. Author contribution

GDP and PC: experiment design and coordination; LG: sample collection, preparation and molecular analysis; SF: morphological identification; FC: GIS analysis and mapping; LG and GDP: manuscript writing; MQ and SF: critical revision and suggestions. All authors read and approved the manuscript.

6. Funding

This work was founded by BeeVesuvius Project (Grant agreement between Vesuvius National Park Institution and Institute for Sustainable Plant Protection – National Research Council). FC was funded by the Italian PhD Program in Artificial Intelligence, Department of Biology at University of Naples Federico II and 3Bee s.r.l.

7. Acknowledgements

We want to thank the - Biodiversity Group of Carabinieri for their support in the Integral Natural Reserve.

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