Assessing the conservation status of diurnal Lepidoptera in the Vesuvius National Park

by *Lorenzo Goglia*[*], *Flavia Vittoria Chianese*[**], *Paola Conti*[***], *Gennaro Di Prisco*[****]

Abstract

The conservation status of the species collected and observed in the Vesuvius National Park (VNP) and included in the Red List of Italian butterflies has not been monitored for 17 years; therefore, there is currently no knowledge of how the biodiversity and populations of Rhopalocera have changed over these years. A list of 72 species of Lepidoptera with diurnal behaviour is reported. Five species are mentioned for the first time for the Park. *Catocala puerpera* (Giorna, 1791) is mentioned in Campania for the first time. Of particular interest are the findings of: *Euplagia quadripunctaria* (Poda, 1761), this specie is included in European Community Habitats Directive (92/43/EEC); *Cacyreus marshalli* Butler, 1898, alien specie of South Africa origin; *Glaucopsyche iolas* (Ochsenheimer, 1816), that is considered "almost threatened" following IUNC Red List.

Key words: checklist, Lepidoptera, Vesuvius National Park, red list, biodiversity, pollinators.

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[*] Institute for Sustainable Plant Protection – The Italian National Research Council (IPSP-CNR) Piazzale Enrico Fermi, 1 – 80055 Portici (NA), Italy.
[**] Institute for Sustainable Plant Protection – The Italian National Research Council (IPSP-CNR) Piazzale Enrico Fermi, 1 – 80055 Portici (NA), Italy; Department of Biology – University of Naples Federico II – via Cinthia 26 - 80126 Naples (NA), Italy.
[***] Vesuvius National Park Institution - via Palazzo del Principe presso il Castello Mediceo – 80044, Ottaviano (NA), Italy.
[****] Institute for Sustainable Plant Protection – The Italian National Research Council (IPSP-CNR) Piazzale Enrico Fermi, 1 – 80055 Portici (NA), Italy. Corresponding author, e-mail: gennaro.diprisco@cnr.it.

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1. Introduction

Lepidoptera, with their morphological and behavioral diversity, constitute a significant component of global biodiversity. Butterfly adults are incidental pollinators, butterfly larvae are important herbivores (Scoble, 1992), and all life stages serve as food sources for birds and other animals. Worldwide declines in insect diversity and abundance are increasingly well documented (Wagner, 2020; Leone et al., 2022).

These species are subject to anthropogenic pressures that threaten their survival and the stability of the ecosystems in which they operate. Through the drafting of the checklist, with a focus on environmental sustainability, particular attention has been given to species most sensitive to changes and/or those protected by current directives.

Last updates on diurnal Lepidoptera of the Park and surroundings were made by Vegliante and Zilli in 2007 which report 63 taxa for Vesuvius National Park (VNP); before them, 44 species were traced by Volpe et al. in 1999 and 2000.

The conservation status of the species collected and observed in the VNP and included in the Red List of Italian butterflies has not been monitored for 17 years; therefore, there is currently no knowledge of how the biodiversity and populations of Rhopalocera have changed over these years. This assessment is even more essential in a territory like that of the VPN, which can be considered an “ecological island” due to the intense urbanization of the surrounding area, separating it from the nearest mountainous systems.

Here we would like to assess the conservation status of Rhopalocera species within the VPN, following the guidelines provided by the IUCN according to ISPRA guidelines (Directive n. 44/2019), as well as identifying any species protected under European directives.

2. Materials and methods

The Park spans across 8.482 hectares, encompassing the territories of 13 municipalities. The Somma-Vesuvius volcanic complex is located near Naples, Southern Italy, and comprises two parts: the older Mt. Somma and the younger Mt. Vesuvius. The most active structures are the NE-SW and N-S ones, with eruptions occurring in eccentric craters. Vesuvius has been active since 1631, with cycles of quiescence and explosive eruptions. The proximity to the Apennine chain and seismogenic areas may have a role in the volcanic activity (Berrino et al., 1993). The vascular flora of Somma-Vesuvius

currently consists of 744 entities, adding all citations from Vesuvian floristic literature, the total entities surpass 1000. Endemic species represent 2% of the area. The Vesuvius flora includes 19 species of Orchidaceae, that is the 2.5% of the overall species count (Motti et al., 2009).

Within Vesuvius National Park boundaries, 10 hot-spots characterized by diverse biocenoses as sampling points (VNP001-VNP010) were identified. 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-VNP031) (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	Somma-Vesuvius (NA)	Vegliante and Zilli, 2007
VNP012	Sant'Anastasia (NA), 350 m/a.s.l.	Vegliante and Zilli, 2007
VNP013	Vesuvius National Park, 800 m/a.s.l.	Vegliante and Zilli, 2007
VNP014	Saant'Anastasia (NA), 350 m/a.s.l.	Vegliante and Zilli, 2007
VNP015	Sant'Anastasia (NA), 190-250 m/a.s.l.	Vegliante and Zilli, 2007
VNP016	Vesuvius National Park, 400 m/a.s.l.	Vegliante and Zilli, 2007
VNP017	Torre del Greco (NA)	Vegliante and Zilli, 2007
VNP018	Ercolano (NA), 880-965 m/a.s.l.	Vegliante and Zilli, 2007
VNP019	Ercolano (NA), 500-525 m/a.s.l.	Vegliante and Zilli, 2007
VNP020	Ottaviano (NA)	Vegliante and Zilli, 2007
VNP021	Mount Somma, 600 m/a.s.l.	Vegliante and Zilli, 2007
VNP022	Ercolano (NA), 870-965 m/a.s.l.	Vegliante and Zilli, 2007
VNP023	Mount Somma, Vesuvius National Park	Vegliante and Zilli, 2007
VNP024	Portici (NA)	Vegliante and Zilli, 2007

Cod.	Place	Reference
VNP025	Vesuvius	Vegliante and Zilli, 2007
VNP026	Somma Vesuviana (NA), 465 m/a.s.l.	Vegliante and Zilli, 2007
VNP027	Sant'Anastasia (NA), 350 m/a.s.l.	Vegliante and Zilli, 2007
VNP028	Ottaviano (NA), 275 m/a.s.l.	Vegliante and Zilli, 2007
VNP029	Ercolano (NA)	Vegliante and Zilli, 2007
VNP030	Boscoreale (NA), 300 m/a.s.l.	Vegliante and Zilli, 2007
VNP031	Somma vesuviana (NA), 450 m/a.s.l.	Vegliante and Zilli, 2007

The method used for sampling was the semi-quantitative transects (Pollard and Yates, 1994), a permanent vegetated corridor along which specimens are identified and/or collected and counted during a 50 minute walk.

Specimens were collected using an entomological net. The preparation and identification of Lepidoptera were carried out using the classic methods commonly employed for this order. The dissection of genitalia was carried out following Robinson (1976).

The hindleg of all specimens were isolated and stored at -20°C for the subsequent molecular analysis, that was carried out on 5 doubtful specimens using the DNA Barcoding approach involving the amplification of the COI gene.

Molecular analyses were carried out using partial sequences of the COI gene. The DNA extraction have been involved using Chelex resin protocol.

The COI gene have been amplified using standard primers: LCO1490 (F5'-GGTCAACAAATCATAAAGATATTGG-3') and HCO2198 (R5'-TAAACTTCAGGGTGACCAAAAAATCA-3') as described by Folmer et al. in 1994.

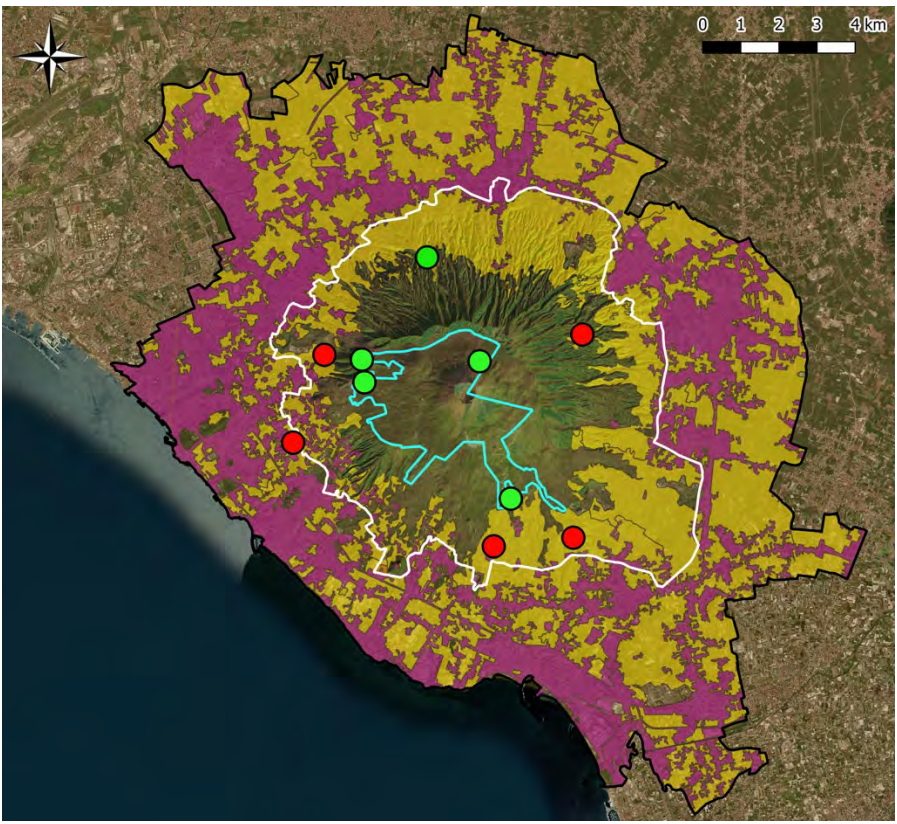
Polymerase chain reaction (PCR) amplification was carried out using 50 µl of PCR master mix with 5 µl of 10X Taq buffer, 3 µl of 1.5 mM $MgCl_2$, 2 µl of 5 mM dNTP, 2.5 µl of 10 µM of each primer, 1.25U Taq DNA Polymerase recombinat (Thermo Fisher Scientific) and 1 µl of DNA. The thermal cycling parameters 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 El-

evation Model utilized with a resolution of 10 meters 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 (aquamarine), Man and the Biosphere Programme area (MAB), (white), and relative MAB buffer zone (black). Agricultural landscape (yellow ochre) is composed of five different classes including vineyards, orchards, citrus groves, extensive and intensive agriculture, while urban landscape (purple) includes urban fabric and production and commercial sites



3. Results

To compile the species list, the indications reported by Goater et al. (2003), Vegliante and Zilli (2007), Witt and Ronkay (2011) and Leraut (2016) were followed.

In the list, species mentioned in the literature are marked with "*", while those analyzed molecularly are indicated with "**", where % of identification is more of 99.30. The following list indicates the locations where species were found and the plants associated with them. Missing data are marked with "?".

The distribution of the species, that is not showed in the list, was taken mostly from Tolman and Lewington (2008 and 2014) and Leraut (2016) considering also Parenzan and Scalercio (1996), Sciarretta and Zilli (1998), Goater et al. (2003), Vegliante and Zilli (2007), Agius (2008), Huemer and Morandini (2008), Huemer and Morandini (2009), Wolf-Christian et al. (2017) and Favilli and Piazzini (2022).

The chorotype of each species was taken from Vigna Taglianti et al. (1992, 1999) and Parenzan (1994).

Total species of Lepidoptera collected from the entomological expeditions was 46, to which it has added 26 species collected in the past by other entomologists, up to a total of 72 taxa.

LIST OF TAXA

Family Papilionidae

*****Iphiclides podalirius* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP004: 1 ♀, 24.V.2022.
CHOROTYPE: Sibero-European.

***Papilio machaon* Linnaeus, 1758**
MATERIAL OBSERVED: VNP001: 1 ?, 8.VI.2022; VNP001: 1 ?, 21.VI.2022; VNP001: ?, 7.VII.2022; VNP001: 1 ?, 14.IX.2022.
CHOROTYPE: Holarctic.

Family Hesperiidae

****Carcharodus alceae* (Esper, 1780)**
MATERIAL RECORDED: VNP011: ?, ? (Vegliante and Zilli, 2007).

CHOROTYPE: Centralasiatic-Europeo-Mediterranean (*sensu* Vigna Taglianti *et al*., 1999) with extension to Arabic Peninsula.

***Carcharodus floccifera* (Zeller, 1847)**
MATERIAL EXAMINED: VNP003: 1 ♀, 16.VI.2022.
CHOROTYPE: Centralasiatic-Europeo-Mediterranean.

****Erynnis tages* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP011: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

****Pyrgus malvoides* (Elwes and Edwards, 1897)**
MATERIAL RECORDED: VNP011: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: W-European.

***Spialia sertorius* (Hoffmannsegg, 1804)**
MATERIAL EXAMINED: VNP003: 1 ♀, 27.VII.2022.
CHOROTYPE: W-European (*sensu* Vigna Taglianti *et al*., 1999) with extension to N-Africa.

***Thymelicus acteon* (Rottemburg, 1775)**
MATERIAL EXAMINED: VNP009: 1 ♂, 7.VI.2022; VNP009: 1 ♂, 8.VI.2022; VNP008: 1 ♀, 6.VII.2022; VNP008: 1 ♂, 21.VII.2022.
CHOROTYPE: Europeo-Mediterranean.

****Thymelicus sylvestris* (Poda, 1761)**
MATERIAL RECORDED: VNP011: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

****Hesperia comma* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP011: ?, VII-VIII (Vegliante and Zilli, 2007).
CHOROTYPE: Sibero-European.

***Ochlode sylvanus* (Esper, 1777)**
MATERIAL EXAMINED: VNP004: 1 ♀, 7.VI.2022; VNP008: 1 ♀, 21.VI.2022; VNP007: 1 ♀, 25.V.2023; VNP007: 1 ♀, 30.V.2023.
CHOROTYPE: Asiatic-European.

*****Gegenes pumilo* (Hoffmannsegg, 1804)**
MATERIAL EXAMINED: VNP007: 1 ?, 2.VIII.2023.
CHOROTYPE: Afrotropico-Indo-Mediterranean.

Family Pieridae

***Leptidea sinapis* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP013: ?, ?; VNP014: ?, 8.VI; VNP015: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

***Aporia crataegi* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP016: ?, VI; VNP017: ?, 10.VI.1954 (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Pieris rapae* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP010: 1 ♂, 9.V.2022; VNP003:1 ♂, 16.VI.2022.
CHOROTYPE: Subcosmopolitan.

***Pieris mannii* (Mayer, 1851)**
MATERIAL EXAMINED: VNP004: 2 ♂♂, 22.VI.2022; VNP001: 1 ♂, 27.IV.2023.
CHOROTYPE: Europeo-Mediterranean.

***Pieris napi* (Linnaues, 1758)**
MATERIAL RECORDED: VNP020: ?, ?; VNP017: ?, ?; VNP018: ?, 6.VI; VNP019: ?, 8.VI;VNP0015: ?, 9.VI; VNP011: ?, 8.VI and 14.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Pieris brassicae* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP004: 1 ♀, 24.V.2022; VNP004: 1 ♂, 21.VI.2022; VNP004: 1 ♂, 6.VII.2022; VNP008: 1 ♀, 6.VII.2022; VNP004: 1 ♂, 20.VII.2022.
CHOROTYPE: Palearctic.

***Pontia edusa* (Fabricius, 1777)**
MATERIAL EXAMINED: VNP003: 2 ♀♀, 4.VIII.2022; VNP008: 1 ♀, 18.VII.2023.
CHOROTYPE: Asiatic-European.

***Euchloe ausonia* (Hübner, 1804)**
MATERIAL RECORDED: VNP021: ?, ?; VNP011: ?, ? (Vegliante and Zilli, 2007).

CHOROTYPE: Centralasiatic-Europeo-Mediterranean.

***Anthocharis cardamines* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP010: 1 ♂, 24.X.2022; VNP010: 1 ♀, 9.V.2022.
CHOROTYPE: Asiatic-European.

***Colias croceus* (Fourcroy, 1785)**
MATERIAL EXAMINED: VNP003: 1 ♂, 10.V.2022; VNP009: 1 ♂, 11.V.2022; VNP003: 1 ♂, 16.VI.2022; VNP003: 1 ♂, 18.VII.2023; VNP008: 1 ♂, 31.VII.2023.
CHOROTYPE: W-Palearctic.

****Gonopteryx cleopatra* (Linnaeus, 1767)**
MATERIAL RECORDED: VNP023: ?, VI, VII; VNP022: ?, 4.VII (Vegliante and Zilli, 2007).
CHOROTYPE: European (*sensu* Vigna Taglianti *et al*., 1999) with extension to N-Africa and Middle East.

***Gonopteryx rhamni* (Linnaeus, 1758)**
MATERIAL OBSERVED: VNP004: 1 ?, 21.VII.2022.
CHOROTYPE: Palearctic.

Family Nymphalidae

****Libythea celtis* (Laicharting, 1782)**
MATERIAL RECORDED: VNP024: ?, X (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Charaxes jasius* (Linnaeus, 1767)**
MATERIAL EXAMINED: VNP009: 1 ♂ and 1 ♀, 14.IX.2022.
CHOROTYPE: Afrotropico-Mediterranean.

***Pararge aegeria* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP002: 1 ♀, 10.V.2022; VNP007: 1 ♀, 2.VII.2023; VNP002: 1 ♂, 2.VIII.2022.
CHOROTYPE: European (*sensu* Vigna Taglianti *et al*., 1999) with extension to N-Africa and Middle East.

****Lasiommata maera* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP017: ?, 14.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Lasiommata megera* (Linnaeus, 1767)**
MATERIAL EXAMINED: VNP002: 1 ♀, 10.V.2022; VNP007: 1 ♂, 11.V.2022.
CHOROTYPE: European (*sensu* Vigna Taglianti *et al*., 1999) with extension to N-Africa and Middle East.

****Coenonympha pamphilus* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP023: ?, ?; VNP011: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

***Pyronia cecilia* (Vallantin, 1894)**
MATERIAL EXAMINED: VNP003: 1 ♀, 4.VIII.2022.
CHOROTYPE: Mediterranean.

***Maniola jurtina* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP003: 1 ♀, 23.V.2022; VNP008: 1 ♂, 21.VI.2022; VNP008: 2 ♂♂, 6.VII.2022; VNP004: 1 ♀, 21.VII.2022; VNP003: 1 ♀, 4.VIII.2022; VNP003: 1 ♀, 20.VI.2023.
CHOROTYPE: Palearctic.

****Hipparchia fagi* (Scopoli, 1763)**
MATERIAL RECORDED: VNP023: ?, VII-VIII; VNP025: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Centralasiatic-European.

***Hipparchia statilinus* (Hufnagel, 1766)**
MATERIAL EXAMINED: VNP005: 2 ♂♂, 29.VIII.2022; VNP005: 2 ♂♂, 3.X.2022.
CHOROTYPE: Turano-Europeo-Mediterranean.

****Limenitis reducta* Staudinger, 1901**
MATERIAL RECORDED: VNP020: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Centralasiatic-European.

***Vanessa atalanta* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP010: 1 ♂, 24.X.2022; VNP004: 1 ♂, 18.VII.2023.
CHOROTYPE: Subcosmopolitan.

***Vanessa cardui* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP002: 1 ♀, 21.VI.2022; VNP008: 1 ?,

21.VI.2022; VNP002: 1 ♂, 2.VIII.2022.
CHOROTYPE: Subcosmopolitan.

***Polygonia c-album* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP004: 1 ♀, 18.VII.2022.
CHOROTYPE: Palearctic.

****Polygonia egea* (Cramer, 1775)**
MATERIAL RECORDED: VNP023: ?, ?; VNP027: ?, 8.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Centralasiatic-European.

****Aglais io* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP023: ?, VI; VNP028: ?, 9.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

****Nymphalis polychloros* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP022: ?, 17.VII; VNP018: ?, 6.VI; VNP023: ?, 2.VIII; VNP027: ?, 8.VI; VNP015: ?, 6.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Argynnis paphia* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP004: 1 ♀, 6.VII.2022; VNP004: 1 ♀, 18.VII.2023.
CHOROTYPE: Palearctic.

***Issoria lathonia* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP007: 2 ♂♂, 27.IV.2023; VNP001: 1 ♀, 7.VI.2023.
CHOROTYPE: Centralasiatic-European.

***Melitaea phoebe* (Goeze, 1779)**
MATERIAL EXAMINED: VNP003: 1 ?, 27.VII.2022.
CHOROTYPE: Asiatic-European.

***Melitaea didyma* (Esper, 1778)**
MATERIAL EXAMINED: VNP003: 1 ♂, 16.VI.2022; VNP003: 1 ♂, 8.VII.2022; VNP003: 1 ♂, 3.X.2022; VNP003: 1 ♀, 4.VII.2022; VNP003: 1 ♂, 11.IX.2023.
CHOROTYPE: Asiatic-European.

***Melitaea athalia* (Rottemburg, 1775)**
MATERIAL EXAMINED: VNP003: 1 ♂, 20.VI.2022; VNP008: 1 ♀, 21.VI.2022; VNP008: 1 ?, 6.VII.2022; VNP003: 1 ♂ and 1 ♀, 31.VII.2023; VNP003: 1 ♂, 4.VIII.2023; VNP003: 1 ?, 4.VIII.2023.
CHOROTYPE: Asiatic-European.

Family Lycaenidae

***Callophrys rubi* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP008: 1 ♂, 9.V.2022; VNP008: 1 ♂, 23.V.2022.
CHOROTYPE: Palearctic.

***Satyrium ilicis* (Esper, 1779)**
MATERIAL EXAMINED: VNP005: 1 ♀, 6.VII.2022.
CHOROTYPE: Asiatic-European.

***Lycaena phlaeas* (Linnaeus, 1761)**
MATERIAL EXAMINED: VNP007: 1 ♀, 11.V.2022; VNP008: 1 ♂, 23.V.2022; VNP008: 2 ♀♀, 21.VI.2022; VNP006: 1 ♀, 20.VII.2022; VNP008: 1 ♀, 21.VII.2022; VNP008: 1 ♂, 2.VIII.2022; VNP007: 1 ♂, 14.IX.2022.
CHOROTYPE: Subcosmopolitan.

***Lycaena alciphron* (Rottemburg, 1775)**
MATERIAL EXAMINED: VNP008: 1 ♂ and 1 ♀, 21.VI.2022.
CHOROTYPE: Palearctic.

***Lampides boeticus* (Linnaeus, 1767)**
MATERIAL EXAMINED: VNP003: 2 ♂♂ and 2 ♀♀, 27.VII.2022; VNP008: 1 ♂ and 1 ♀, 2.VIII.2022; VNP009: 1 ♂, 3.VIII.2022; VNP008: 1 ♂ and 1 ♀, 28.VIII.2022; VNP002: 1 ♀, 15.IX.2022; VNP002: 1 ♂, 4.VII.2023; VNP003: 1 ♂, 31.VII.2023.
CHOROTYPE: Subcosmopolitan.

***Leptotes pirithous* (Linnaeus, 1767)**
MATERIAL EXAMINED: VNP003: 1 ?, 4.VIII.2022; VNP006: 1 ♂, 14.IX.2022.
CHOROTYPE: Afrotropico-Mediterranean.

***Cacyreus marshalli* Butler, 1898**
MATERIAL EXAMINED: VNP008: 2 ♂♂, 21.VII.2022; VNP010: 1 ♂,

2.VIII.2022.
CHOROTYPE: Afrotropico-Mediterranean (*sensu* Vigna Taglianti *et al*., 1999) with extension to Europe.

***Cupido osiris* (Meigen 1829)**
MATERIAL RECORDED: VNP011: ?, ?(Vegliante and Zilli, 2007).
CHOROTYPE: Centralasiatic-European.

***Cupido minimus* (Fuessly, 1775)**
MATERIAL EXAMINED: VNP003: 1 ♂, 16.VI.2022; VNP005: 1 ?: 13.IV.2022.
CHOROTYPE: Sibero-European.

****Glaucopsyche iolas* (Ochsenheimer, 1816)**
MATERIAL EXAMINED: VNP003: 1 ♂, 23.V.2022; VNP004: 1 ♂ and 1 ♀, 21.VI.2022; VNP003: 1 ♀, 8.VII.2022; VNP008: 1 ♀, 2.VIII.2022; VNP008: 1 ♀, 6.VI.2023.
CHOROTYPE: Europeo-Mediterranean.

***Glaucopsyche alexis* (Poda, 1761)**
MATERIAL EXAMINED: VNP004. 1 ♀, 10.V.2022; VNP005: 1 ♀, 13.IV.2023; VNP005: 1 ?, 26.IV.2023.
CHOROTYPE: Palearctic.

***Phengaris arion* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP029: ?, V.1838 (Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

***Celastrina argiolus* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP010: 1 ♂, 14.IV.2022.
CHOROTYPE: Holarctic.

***Plebeius argus* (Linnaeus, 1758)**
MATERIAL RECORDED: VNP011: ?, ?(Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

***Aricia agestis* (Denis and Schiffermüller, 1775)**
MATERIAL EXAMINED: VNP008: 1 ♂, 23.V.2022; VNP008: 1 ♂ and 1 ♀, 6.VII.2022; VNP008: 1 ♀, 28.VIII.2022; VNP008: 1 ♀, 21.VII.2022; VNP008: 1 ♀, 28.VIII.2022.
CHOROTYPE: Asiatic-European.

***Plebeius argyrognomon* (Bergsträsser, 1779)**
MATERIAL RECORDED: VNP030, VNP031, 14.VI; VNP026, 9.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Sibero-European.

***Cyaniris semiargus* (Rottemburg, 1775)**
MATERIAL RECORDED: VNP015: ?, 6.VI; VNP012: ?, 8.VI; VNP026: ?, 9.VI (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Polyommatus amandus* (Schneider, 1792)**
MATERIAL RECORDED: VNP030: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Palearctic.

***Polyommatus icarus* (Rottemburg, 1775)**
MATERIAL EXAMINED: VNP009: 1 ♂, 11.V.2022; VNP003: 2 ♂♂, 16.VI.2022; VNP009 1 ♂, 21.VII.2022; VNP008: 1 ♂, 21.VII.2022; VNP003: 1 ♀, 4.VIII.2022; VNP008: 1 ♂, 28.VIII.2022; VNP007: 1 ♀, 7.VI.2022; VNP007: 1 ♂, 7.VI.2022.
CHOROTYPE: Asiatic-European.

***Polyommatus daphnis* (Denis and Schiffermüller, 1775)**
MATERIAL RECORDED: VNP030: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: European with Caucasian extension.

***Lysandra bellargus* (Rottemburg, 1775)**
MATERIAL RECORDED: VNP030: ?, ? (Vegliante and Zilli, 2007).
CHOROTYPE: Asiatic-European.

Family Erebidae

****Arctia villica* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP008: 1 ♀, 23.V.2022.
CHOROTYPE: Palearctic.

***Euplagia quadripunctaria* (Poda, 1761)**
MATERIAL EXAMINED: VNP004: 1 ♂, 18.VII.2022.
CHOROTYPE: W-Palaearctic.

***Amata phegea* (Linnaeus, 1758)**
MATERIAL OBSERVED: VNP002: ?, V-VII.

CHOROTYPE: European.

***Catocala puerpera* (Giorna, 1791)**
MATERIAL COLLECTED: VNP008: 1 ♂, 11.IX.2023.
CHOROTYPE: Centralasiatic-Mediterranean.

Family Sphingidae

***Macroglossum stellatarum* (Linnaeus, 1758)**
MATERIAL EXAMINED: VNP002: 1 ♀, 7.VI.2022.
CHOROTYPE: Palearctic.

A biogeographic study on the Lepidoptera found in Vesuvius National Park, using chorological analysis, is reported. It can be noted that there are few Subcosmopolitan (6.94%) and Holartic (2.78%) species. More than 70% of the species show a wide Palaearctic distribution. In this grouping, the *taxa* with the chorotypes Palearctic (24.99%), Asiatic-European (22.22%), Centralasiatic-European (6.94%), Sibero-European (5.55%), and Europeo-Mediterranean (4.17%) are well represented. Fewer are W-Palearctic (2.78%), Centralasiatic-Europeo-Mediterranean (2.78%), Centralasiatic-Europeo-Mediterranean with extension to Arabic Peninsula (1.39%), Centralasiatic-Mediterranean (1.39%), Turano-Europeo-Mediterranean (1.39%). Less than 10% of the collected entities are Lepidoptera with European distribution; the elements belonging to this chorotype show European with extension to N-Africa and Middle East (4.17%), European (1.39%), European with Caucasian extension (1.39%), W-European (1.39%) and W-European with extension to N-Africa (1.39%). The Mediterranean distribution *taxa* is shown only by Mediterranean (1.39%). Finally, Afrotropico-Mediterraenan (2.78%), Afrotropico-Indo-Mediterranean (1.39%), Afrotropico-Mediterranean with extension to Europe (1.39%) chorotype are reported.

4. Discussion

During entomological expeditions carried out in 2022-2023 in VNP, 46 species of Lepidoptera were collected or observed, to which 26 species collected in the past by other entomologists were added, up to a total of 72 species. For Lepidoptera Rhopalocera, the two most representative families are Nymphalidae and Lycaenidae; which have 22 and 21 *taxa* each, respectively;

followed by Pieridae (12), Hesperiidae (10) and Papilionidae (2). Five species of Lepidoptera Heterocera, with diurnal behaviour, belonging to the families Erebidae and Sphingidae have been studied.

Molecular analyses carried out on particularly challenging samples confirm the accuracy of the morphological identification. Specifically, the identification percentage and query cover exceed 99.30% and 94%, respectively.

From a faunistic point of view, it was possible to add 5 new species previously unknown for the Vesuvius National Park: *Charcharodus floccifera* (Zeller, 1847); *Polygonia c-album* (Linnaeus, 1758); *Argynnis paphia* (Linnaeus, 1758); *Melitaea phoebe* (Goeze, 1779); *Euplagia quadripunctaria* (Poda, 1761) (Fig. 2). One new specie for Campania region *Catocala puerpera* (Giorna, 1791) is recorded (Figg. 2, 3).

Of particular significance is the report of *Glaucopsyche iolas* (Ochsenheimer, 1816), that is considered "almost threatened" (IUNC Red List) in Italy (Balletto et al., 2016); this specie is rare and poorly known in Italy, occurring with isolated and transitory populations, closely dependent on fluctuations of the host plant, the uncommon and localized *Colutea arborescens* L. Interesting is also the findings of *Euplagia quadripunctaria* (Poda, 1761), this specie is included in Annex II of the European Community Habitats Directive 92/43/EEC as «species of Community interest which require strict protection and whose conservation requires the designation of special areas of conservation» (Baldizzone et al., 2022); anyway *E. quadripunctaria* cannot be considered rare but is threatened with extinction due to human interventions that compromise and reduce the extent of its habitat (Gobbi et al., 2007). At the end the report of *Cacyreus marshalli* Butler, 1898, alien specie of South Africa origin, accidentally introduced into Italy in the late 1990s and widley spread throughout the country (Trematerra and Parenzan, 2003).

It is possible to observe that the number of *taxa* from 2007 to 2023 is decreased; this might be due to climate changes or environment pollution. Another factor is that some species may be strongly related to the type of vegetation that was not investigated in our survey. For example, *Carcharodus alceae* (Esper, 1780) was observed in the Park recently (pers. comm.) but is not collected during our transects.

Moreover, the elaboration of checklist allows us to investigate the health of the environment, to assess the diversity of Lepidoptera present in a given

area, the impact of human activity on insect populations. It has to be considered that VNP represent the green lung of the metropolitan city of Naples and its province. It is important to note that this area is densely populated and heavily influenced by human activities, leading to high environmental

pollution. The particular political and social situation in the province of Naples has a negative impact on the surrounding environment. It is for this reason that the study on insects and, precisely, Lepidoptera as environmental indicators may provide valuable insights into the environmental health. If necessary, targeted interventions to preserve biodiversity in an area with a strong landscape, historical, cultural and environmental value may be carried out.

5. Author contribution

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

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Figure 2 – Specie collected in Vesuvius National Park: Argynnis paphia (Linnaeus, 1758) (A); Polygonia c-album (Linnaeus, 1758) (B); Euplagia quadripunctaria (Poda, 1761) (C); Catocala puerpera (Giorna, 1791) (D).

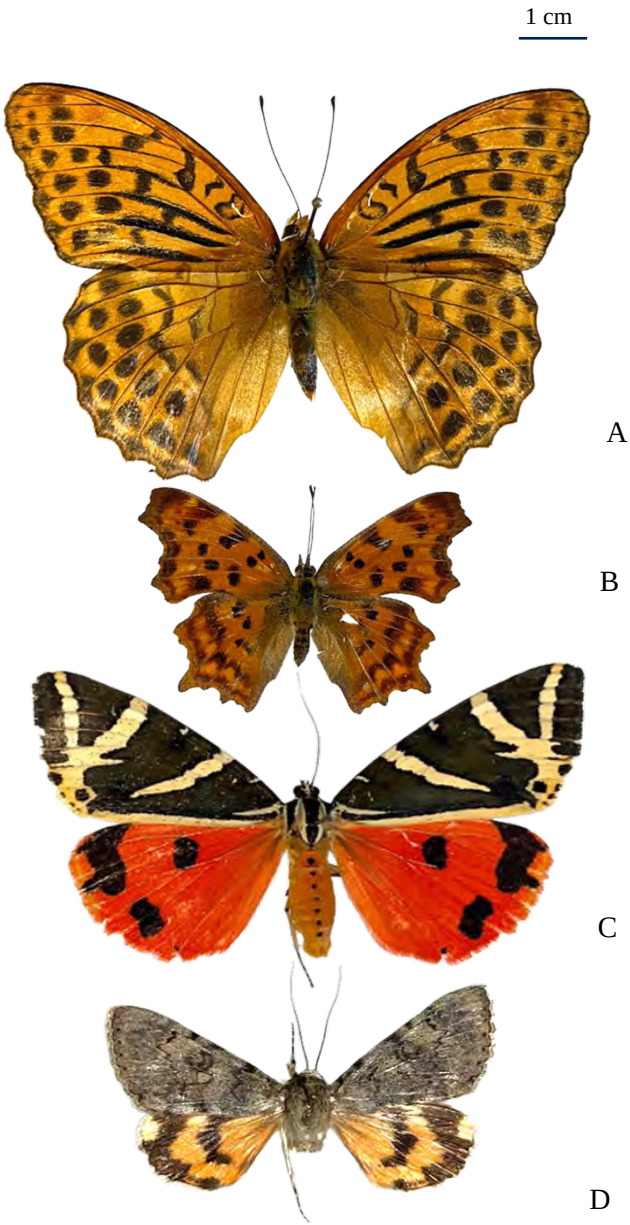

Figure 3 – Male genitalia of Catocala puerpera (Giorna, 1791).