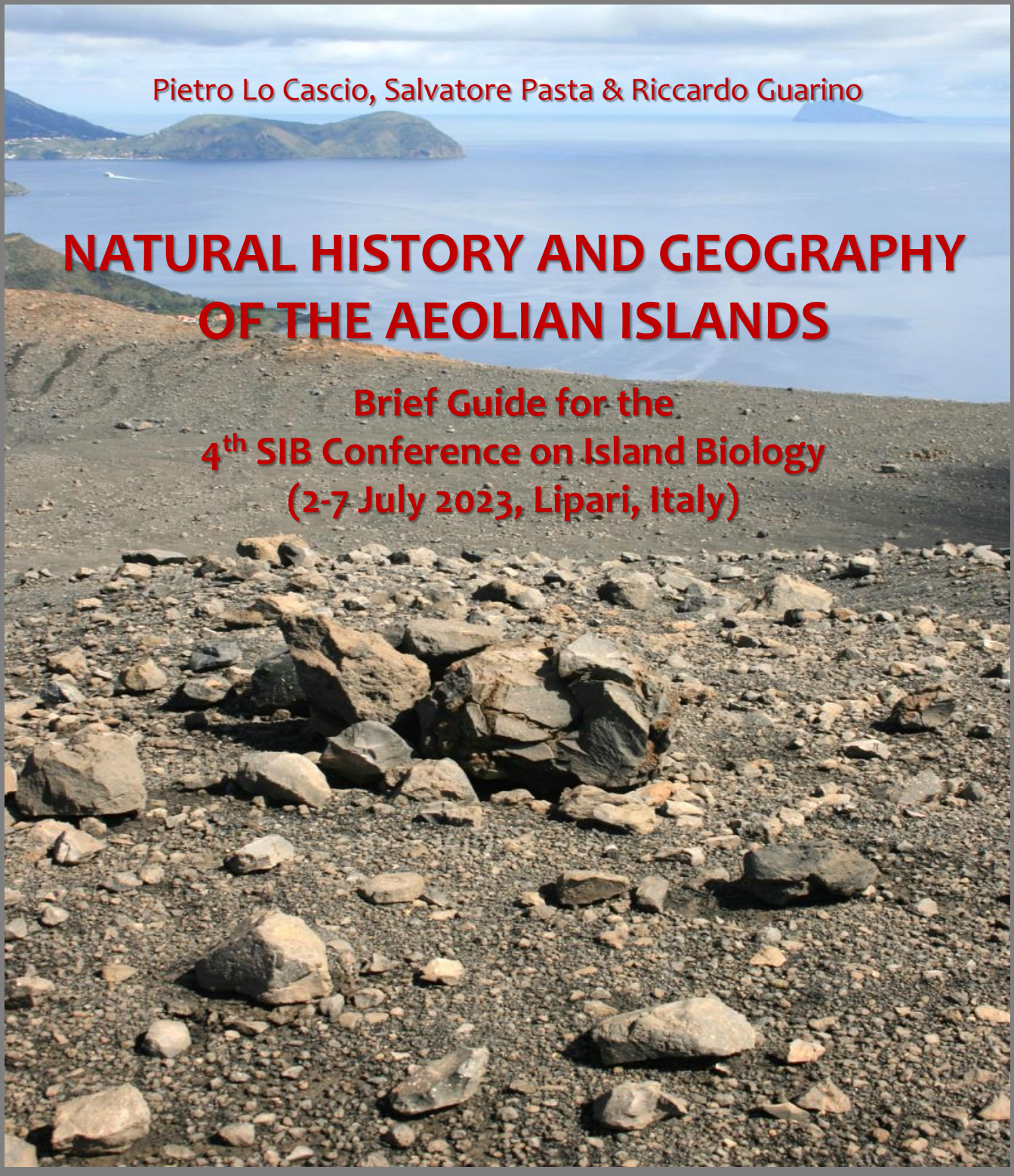
Pietro Lo Cascio, Salvatore Pasta & Riccardo Guarino

NATURAL HISTORY AND GEOGRAPHY OF THE AEOLIAN ISLANDS

Brief Guide for the 4th SIB Conference on Island Biology (2-7 July 2023, Lipari, Italy)



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Cover photo: the islands of Lipari and Panarea from the top of Gran Cratere, Vulcano Island (photo: P. Lo Cascio)

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Geographical and historical sketch

The Aeolian Archipelago lies in the southern Tyrrhenian Sea, between 38°21'54" and 38°48'40" latitude North and 14°20'35" and 15°14'70" longitude East of Greenwich. It includes seven main islands (Lipari, Salina and Vulcano in the central sector, Stromboli and Panarea in the north-eastern sector, Filicudi and Alicudi in the western sector) and several uninhabited islets, the largest of which (Basiluzzo, Lisca Bianca, Dattilo, Bottaro) form a small group off the East and North-East coast of the island of Panarea.

The southernmost island is Vulcano, 20 km away from Sicily (Capo Calavà), while Stromboli is the northernmost and also the closest to the Peninsula, from which it is only 55 km away (Capo Vaticano, Calabria).

All the islands belong to the municipality of Lipari, with the exception of Salina, which hosts three municipalities (Leni, Malfa and Santa Marina). Data from the 2015 national census indicate 696 people in Leni, 982 in Malfa, 903 in Santa Marina and 12,807 in Lipari; within the latter municipality, 9,727 people live in Lipari, 1,277 in Vulcano, 825 in Stromboli, 384 in Filicudi, 154 in Alicudi and 438 in Panarea. Lowest density values are known for Alicudi (30.1 inh./km^2), the highest for Lipari (261.4); with the exception of this latter and Panarea (146.3), however, all the islands have a density lower than 100 inh./km^2.

	a	b	c	d	e
LIPARI	37.29	602	224	27.3	0.9
SALINA	26.38	962	320	37.8	3.0
VULCANO	20.87	499	199	19.5	0.9
STROMBOLI	12.19	924	306	54.3	17.5
FILICUDI	9.49	773	267	44.8	16.1
ALICUDI	5.10	676	258	52.5	16.1
PANAREA	3.34	421	143	40.2	14.3

Geographical data of the Aeolian Archipelago: a) surface (km^2); b) maximum elevation (m a.s.l.); c) mean elevation (m a.s.l.); d) minimum distance from mainland (km); e) minimum distance from the nearest island (km).

Lipari


Rocca del Castello


Castellaro

With a surface of 37.3 km², Lipari is the largest island of the archipelago. Apart from the main town, the island has several villages – Canneto, Pianoconte, Quattropani, Acquacalda, Lami, Serra, Pirrera – and areas with sparse but widespread settlements, developed when the agricultural exploitation was very intense.

Lipari has been frequented since the 8th millennium BC, as documented by the obsidian tools found in many Sicilian archaeological sites. However, the first permanent settlement, which arose on the fertile Castellaro plateau, dates only to the mid-6th millennium BC. During the prehistory, obsidian was the main resource for the local economy and was traded throughout the central Mediterranean. Neolithic and Bronze Age settlements are also known for the Rocca del Castello, the volcanic dome that dominates the harbour and the main town, Monte Giardina and Pianoconte.

Despite its natural defensive position, the Castello settlements suffered from periodic devastations: two villages of the Ausonian facies were in fact destroyed between the late 12th and 10th centuries BC.

In the same place was built the acropolis of the Greek town, founded in 580 BC by colonizers from Knidos, who developed an economic-rural model based on collectivism, a rather unusual fact in the albeit diverse Greek world. Along with the surroundings of the Castello, other localities (Bruca, Fontanelle, Piano Greca, Culìa) were occupied, and even after the Roman conquest (2nd century BC), rural settlements experienced further expansion, extending to Monte Giardina, Pignataro di Fuori, Cicirata, Palmeto, and San Nicola.

Instead, a phase of economic and demographic recession marked the centuries between the Late Empire and the advent of the Normans (6th-11th centuries AD). After the Arab occupation (since the 8th century AD) and the conquest of Sicily by the Normans, in 1083 a group of Benedictine monks based in Lipari established a severe system of economic control through concessions of lands in exchange of tributes. The community was already home to 10,000 inhabitants – although according to recent estimates they were no more than 4,000 in 1544, when Lipari was attacked by a pirate fleet under the command of Khayr al-Dīn, known as "Barbarossa". The pirates destroyed the fortified citadel and deported most of the islanders. At the end of XVI century Charles V ordered to rebuild the fortifications and to introduce tax savings, in order to encourage the island's economic recovery. In the following centuries, the history of the island is marked by the alternating political fortunes of Sicily, but the Church retains its strong temporal power and is often involved in "disputes" against the government or – sometimes – the inhabitants, subject to the payment of heavy tithes extended to all productive activities.

Vineyards near Lipari town, 1890.

Above, the pumice quarries in 1970; below, Monte Pilato, the last active volcano of Lipari.

This custom has continued until the Unification of Italy (1860), which coincided with a period of relative prosperity: agricultural activities represented the main source of the local economy and dry raisins and wine were exported throughout Europe.

During the last decade of the 19th century, however, more than 3/5 of the vineyards were destroyed by phylloxera; under these circumstances, monoculture fully showed its inherent fragility.

The following decades were characterised by economic recession, probably aggravated by the fact that in 1926 the fascist government reinstated confinement on the island where hundreds of political opponents were sent. As a consequence, many people left the island looking for chance in extra-European countries; however, migration did not reach in Lipari the dramatic proportions recorded in the rest of the archipelago.

In the second half of the 20th century, the advent of tourism and the resulting socio-economic transformations further undermined the original rural model. During the past few years, however, a reversal of this trend has been taking place through the gradual increase of agriculture (mainly vineyards).

Most of the island surface, however, is currently affected by of the gradual re-naturalization of abandoned fields, a process partially counteracted by recurrent arsons.

Salina

Salina is the second largest island in the archipelago (26.4 km²) and the highest, with Monte Fossa delle Felci reaching 962 m a.s.l.

The oldest settlement, located at Rinicedda (southern slope), dates from the Neolithic and is contemporary with the village of Castellaro on the island of Lipari. There are also other prehistoric sites, one of which – Portella (XV-XIII century BC), on the eastern slope – is surely the best-preserved village in the archipelago.

Monte dei Porri, the western mount of Salina.

After a period of temporary abandonment, Salina was occupied again in the Greek period and continued to develop under the Roman domination, in part due to the exploitation of the Punta Lingua saltpan and the related activities, such as the fish-salting factory of Punta Barone near Santa Marina. It is possible that the island continued to host a small resident community even in the early medieval period, when nearby Lipari and the rest of the archipelago were instead going through a phase of demographic recession.

However, a peak of economic development was reached during the 19th century and was mainly related to the production of wine, malvasia and "passolina" (= dry raisin), which were traded directly by local producers. At that time the island gained also its administrative autonomy: in 1867 a municipality was established, which in 1911 was further divided into the current municipalities of Santa Marina, Malfa and Leni.

However, the destruction of vineyards caused by phylloxera induced a sudden collapse of the local economy: a large part of the inhabitants (6,000 at the end of the 19th century) would be forced to emigrate to extra-European countries.

Since the 1970s, along with the advent of tourism, there has been a revival of agriculture in Salina; this is mainly due to the reorganization of viticulture according to modern and rational criteria, and to the D.O.C. recognition of the "Malvasia" sweet wine obtained in 1974.

The saltpan of Punta Lingua today (left) and in the early XX century (right).

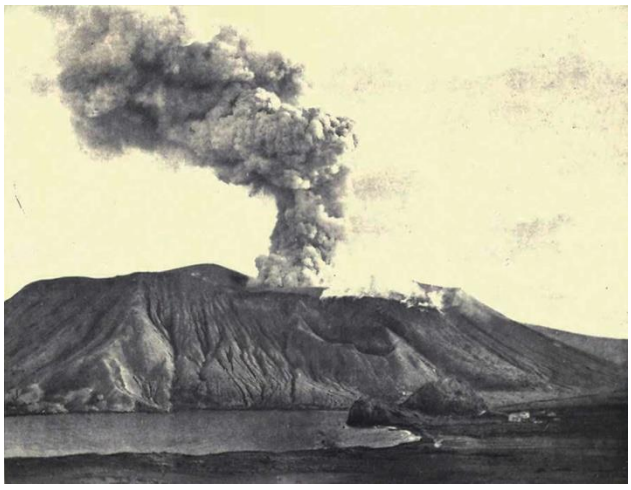
Vulcano

The third largest island of the archipelago (20.9 km^2), Vulcano, is the last to have been inhabited. Although it has been suggested that some artificial caves in the Piano locality may be vestiges of a prehistoric necropolis, archaeological evidence of permanent settlements is lacking. At least until the 17th century, historical sources confirm only seasonal frequentation of the island by inhabitants of nearby Lipari for the exploitation of mining resources and pasturelands. With such premises, Vulcano should represent an exceptional case in the Mediterranean, where islands have almost always undergone intense and long-term processes of anthropization, and should therefore maintain extraordinary conditions of integrity and preservation. But the reality is instead very different from that of a wild paradise.

In the name of tourism development, lost time has been made up with fierce determination, resulting in the vast and haphazard cementing of the Vulcanello peninsula and the surroundings of Gran Cratere. The absence of a pre-existing urban centre, paradoxically, seems to have fostered one of the most ruthless building speculations ever carried out in the Italian small islands.

Some data help to better understand the proportions and the speed of local urban sprawl: Vulcano hosts only 7% of the permanent population of the municipality of Lipari, but has almost 20% of the entire housing stock of the same municipality; the surface of urbanized areas has increased from 5.6 hectares in 1954 to 193 hectares in 2007.

Pasturelands of Piano plateau.



The eruption of 1888-1890 (from Johnston-Laevis, 1891).

Until the 1950s, in fact, there were still only few buildings in Vulcano Porto, including the ruins of the mining plants that – before the last eruption in 1888 – had experienced a relative prosperity. The industry was set up by Vito Nunziante, an officer in the Bourbon army, who in 1813 had started to apply modern techniques to the mining of sulphur, alum, ammonium chloride and boric acid, taking advantage also from the availability of cheap workers that came from the penal colony of Lipari.

In 1860 the mine was purchased by James Stevenson, a Scottish businessman, who also improved the vineyards cultivation and built the "Palazzo dell'Inglese", a house vaguely reminiscent of the crenelated castles of his country. The sulfatara produced 240 tons of sulphur per year, but after the devastating eruption of 1888 this activity was abandoned forever.

In addition to the urban area that occupies Porto, Lentia and Vulcanello, the inhabited areas include scattered settlements in the upper part of the island (Piano) and the small village of Gelso, on the southern coast, whose foundation dates back to the 18th century.

The Porto and Vulcanello in 1950 (left) and nowadays (right).

From left to right, La Fossa volcano, the valley of Rio Grande and Piano plateau .

Left, layers of pyroclastic deposits on the flank of Monte Saraceno; right, the western slopes of La Fossa.

Stromboli

Stromboli is the fourth largest island by surface (12.2 km^2) and the second highest (924 m a.s.l.) of the archipelago. It hosts about 800 inhabitants, mostly concentrated in the homonymous village on the north-eastern side, while about 40 are living in Ginostra, a small village on the south-western side which can only be reached by sea.

The first evidence of human presence on the island dates back to the second half of the 4th millennium BC. During the Middle Bronze Age (first half of the 2nd millennium) a village – subject to ongoing excavation campaigns – was inhabited near San Vincenzo; in the same period, a settlement occurred also at Timpone in Ginostra. Stromboli was also inhabited during Greek and Roman ages, then underwent a phase of abandonment, although occasionally visited by passing travellers. However, recent archaeological investigations have identified a place of worship and some burials dating back to the 13th century.

Since the 17th century, the Lipari's bishop began extensive clearing of the smaller islands to make them cultivable and assigning land through concessions. In the mid-18th century Stromboli already had 700-800 inhabitants, who became more than 2,700 by the end of the 19th century. The local economy was based mainly on agricultural activities, but also several inhabitants engaged in fishing and seafaring, favoured by the island's location between Sicily and the Italian Peninsula.

Terraced vineyards on the N slope of Stromboli with rows of *Saccharum biflorum* used as windbreaks in 1891 (left) ; the same view 130 years later (right) (see Guarino et alii, 2023).

The crisis occurred between the late 19th and early 20th centuries, as well as for the other islands, was mainly due to the devastation of vineyards by phylloxera. But on Stromboli it was enhanced by the eruption of 1930 – six victims, as well as strong damage to homes and crops – that had a strong economic and psychological impact on the population: in fact, many decided to emigrate to extra-European countries.

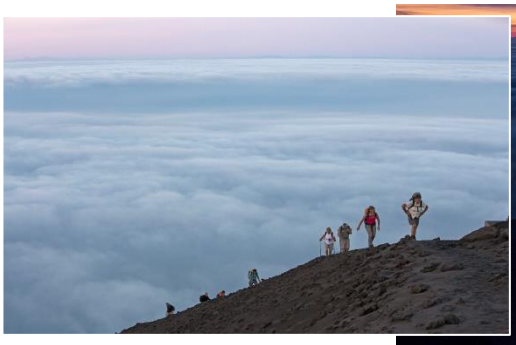
Between 1921 and 1931 the number of residents decreased from over 1,800 to 1,100, and the decline of the local population continued until 1971, when the residents of Stromboli and Ginostra did not exceed 400. A marked change of course in the recent history is due to the extraordinary notoriety achieved after the film "Stromboli terra di Dio", shot in 1949, which launched the island as an evocative and unspoiled tourist destination; and, perhaps, also thanks to the liaison between the director Roberto Rossellini and the actress Ingrid Bergman.

Today the main resource is tourism, sometime not without problematic aspects: for example, the massive occurrence of daily visitors often strains the island's low carrying capacity.

Although fairly busy during the summer season, Ginostra retains almost intact the original characteristics of a small rural island village: it has no real hotel facilities, the roads are sized for walkers and donkeys, and power energy arrived only in 2004.

Stromboli seen from the top of Strombolicchio, early XX century (left), an house damaged by the 1930 eruption (right).

Lava flow on the Sciara del Fuoco, August 2014.



«Strombolian» activity at sunset on Stromboli; currently the access to the top is forbidden.

Filicudi

The "island of palm trees" (Φοινικώδη), so called by Aristotle, is located in the western sector of the archipelago and is the fifth largest island, with an area of 9.5 km^2. Its maximum elevation is 773 m a.s.l. at Fossa Felci, one among many toponyms that Filicudi shares with Salina and that indicate the occurrence of close relations between the communities of the two islands during the last centuries.

A human settlement was probably already present at the end of the 4th millennium BC. However, thanks to the research carried out since the second half of the 20th century by the archaeologists Luigi Bernabò Brea and Madaleine Cavalier, and further carried out by Maria Clara Martinelli, we now have more information about the Bronze Age villages belonging to the Capo Graziano culture. The first was founded at the end of the 3rd millennium BC by people from the Aegean who, although also engaged in fishing and shellfish gathering, were mainly farmers and breeders: the recent archaeobotanical investigations documented a remarkable spread of cereals (barley, spelt, wheat), legumes (field beans, vetch, lentils, peas) and vines (*Vitis vinifera*), whose grape seeds are the oldest evidence of this crop in Italy. Around 1700 BC, the settlement moved to a defensive position on the nearby Capo Graziano hill, while around 1500 BC other people from Sicily replaced the original settlers for two more centuries.

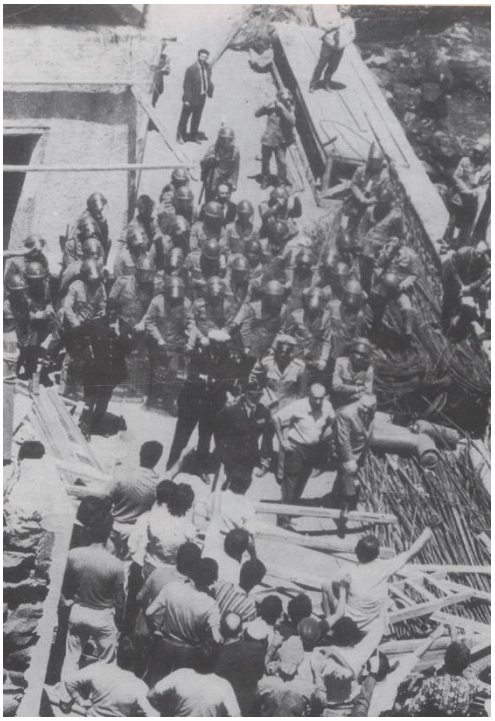
Huts in the Bronze Age village of Capo Graziano.

Stone wheels for mills carved in the rocky shores of Capo Graziano; the activity was abandoned in the early XX century.

According to Pliny and Strabo, during the Greek age the island would have been used as pastureland for livestock farming; however, some archaeological evidence show the occurrence of a (perhaps seasonal) settlement in the plain of the Port since the 4th century BC, which was continuously inhabited under the Roman and – probably – until the Byzantine period.

After a period of abandonment, the island was gradually repopulated during the 17th century. Records of concessions kept in the bishop's archives of Lipari show that between the mid-17th century and 1766, the Church allocated land at least for 1/10 of the island's surface. The local community grew from about 700 inhabitants present at the end of the 18th century to the 2025 counted in 1861, but after this peak the trend became negative, especially during the first half of the 20th century: the 1094 inhabitants counted in 1931 became less than 500 just thirty years later. As a consequence, most part of the terraced landscape, as well as some peripheral settlements (Siccagni, Case Ficarrisi, Zucco Grande) have been almost totally abandoned.

Today the main local resource is tourism, but despite the remarkable environmental and naturalistic value of the island, the presences are concentrated in a rather short season, partly because of the frequent connection difficulties and the island's geographic marginality.
A notable episode of the Filicudi's recent history was the revolt of local people against the government's decision that in 1971 sent 15 "suspected" *mafiosi* in forced residence on the island: a decision that threatened the expectations of the local community just when tourism was beginning. After initial and vain resistance, the islanders decided to leave from the island and moving to Lipari. The government, unable to provide for the logistical needs of the internees, has been backed into a corner. After a month, the mobsters were moved to other locations.



Islanders protest against the police and try to block the landing of mobsters, Filicudi 1971.

Terraced landscape on the southern side of Filicudi.

Capo Graziano seen from a coastal prairie of *Moraea sisyrinchium*.

Columnar lavas at Punta Stimpagnato, southern coast.

Alicudi

Located 52.5 km off the Sicilian coast and extended just 5.1 km^2, Alicudi is one of the most remote and smallest islands of the archipelago, of which it represents the extreme western edge.
It has been inhabited since the Bronze Age (first half of the 2nd millennium BC) and again in Greek and Roman times. But it was not until the 1600s that Alicudi underwent a massive anthropization, through the foundation of the present settlement – initially in the highest part, for defensive reasons – and the construction of terraces and stone-walls along the entire eastern and southern slopes.
Rather than a true urban centre, in fact, the island has scattered residential areas, from the coast (Porto) to 480 m a.s.l. (Montagna), corresponding to several "contrade" (Tonna, Pianicello, Bazzina, Sgurbio, Passo Vigna, Castello and Mulino). The cultivated lands – now almost everywhere abandoned – reach even higher altitudes, such as the plains of Dirittusu and even the hills of Filo dell'Arpa (663 m a.s.l.) and Montagnole (676 m), the highest peaks of the island.
This community, whose main resource was agriculture, grew rapidly until the 19th century, while in the following century suffered from an equally fast decline, decreasing from the 813 inhabitants in 1911 to the 106 recorded in 1991. The terraced area of the island corresponds to approximately 3 km^2.

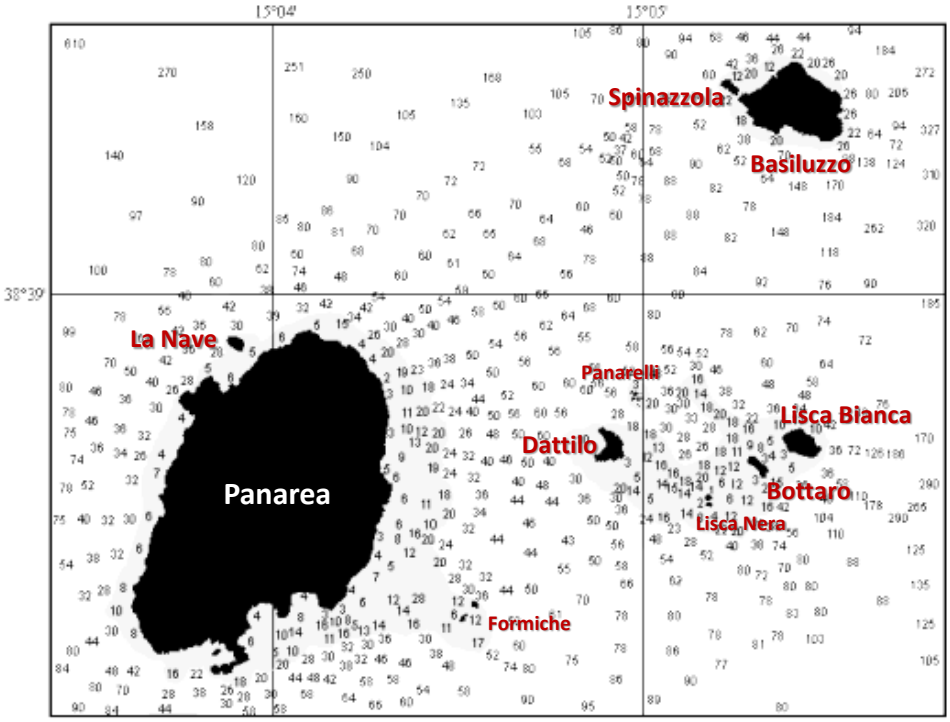
Above: terraced landscape at Pianicello.

When the community reached its maximum population peak in the early 20th century, each islander could theoretically derive his or her livelihood from a mere 3,000 m^2 of arable land: this perhaps strained the island's carrying capacity, and suggests that in the long-term local resources could not have supported such a large population.
Nowadays, tourism-related activities have improved the general life conditions. However, the island still maintain a strong archaic connotation.
For instance, the energy power "arrived" only in 1990, and there is no roadway network, with the exception of a very short stretch linking the ENEL power plant to the harbour. At the same time, after decades of semi-abandonment, agricultural and livestock farming activities are also gradually increasing, although they have much less importance than in the past.

Left: «mannara» (shelter for animals) at Pianicello.

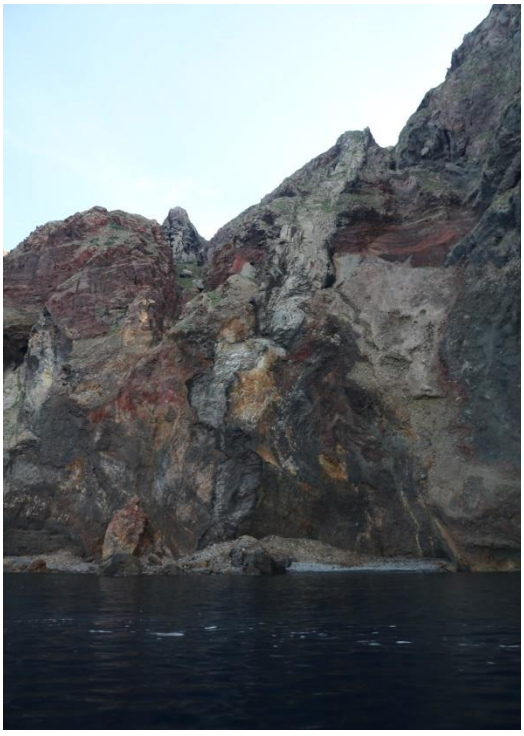
Panarea

Panarea (3.34 km², 421 m a.s.l.) is the smallest and lowest island of the archipelago. Together with its satellite islets, it forms a miniature archipelago, spread over an area of about 25 km²; east of the main island are Lisca Bianca (3.1 ha, 32 m a.s.l.), Dattilo (2.9 ha, 103 m), Bottaro (0.75 ha, 23 m) and the rocks Lisca Nera and Panarelli, while to the northeast, in a more isolated position, are Basiluzzo (28.1 ha, 165 m) and Spinazzola (0.52 ha, 78 m); to the southeast there is also the Formiche, small rocks barely outcropping, while off the northwest coast there is the islet La Nave (0.38 ha, 39 m).
Panarea and some of its satellite islets were frequented by humans as early as the end of the 4th millennium B.C., but the first settlement (Piano Quartara) dates back to the following millennium. It was also inhabited during the Bronze Age, and the most important evidence is the village of Punta Milazzese (15th-13th century B.C.), located in a magnificent defensive position on a narrow sickle-shaped promontory in the southern part.



After the 13th century BC, the island remained uninhabited until the Greek colonization. From that period – as well as from the Roman age – only sporadic traces are known, which however suggest a stable presence on the island or – at least – an intense frequentation of the eastern islets. On the top of Basiluzzo there is a villa (I-II century A.D.) and sparse wall structures, some of which are now submerged, and the islet was probably inhabited until the Byzantine period.
After the Norman conquest, Panarea – like the other islands – became the property of the Church. The most intense phase of anthropization occurs from the 17th century, when cultivable lands are given in concession to settlers, but sometimes squatted by the islanders: in a document of 1661 and kept in the bishop's archives, the bishop Adamo Gentile mentions "usurpers" of the lands of Basiluzzo. More than 3,000 olive trees were planted during the 18th century, a crop that proved particularly suited to the island's physiographic and climatic characteristics, so much so that by the end of the 19th century the Archduke of Habsburg-Lorraine counted nearly 13,000.

Above: Basiluzzo and Stromboli seen from an old path of Panaea. Below: inaccessible cliffs on the NW coast.



However, oliviculture was not successful enough to protect local community from the effects of the economic crisis between the 19th and 20th centuries. Rapid depopulation also took place on this island: from 790 counted in 1911, the number of inhabitants fell to only 272 in 1961.

"*Ho il presentimento che Panarea diverrà nel futuro meta di scrittori e d'artisti che desiderino isolarsi dal mondo, per un certo periodo, e creare*" [I think that Panarea will become in the future a destination for writers and artists who wish to isolate themselves from the world, for a time, and create]: so wrote Fosco Maraini in 1951.

Indeed, starting in the 1960s the island became a destination for elite tourism, which quickly erased the last traces of rural civilization – at least in the village – to transform it into an exclusive residential setting.

On the one hand, this has preserved the island from tacky building choices or outright speculation, such as those perpetrated on Vulcano. On the other hand, however, it has profoundly transformed the island's identity, shaping it according to canons that are only apparently conservative but mirror indeed an exotic imaginary: paradoxically, today Panarea reproduces the typical features of a "small Mediterranean island", but it turns out to be the least "Aeolian" place of the archipelago.

Fortunately, this phenomenon has only marginally affected the natural heritage: not far from the "little white elephant" stores, trendy bars, gardens that look like the realm of *Bougainvillea*, and elegant whitewashed villas that have sprung up in the place of stables, oil mills, or simple peasant houses, there is still an extraordinarily rich and well-preserved nature.

Above: The nice bay of Cala Junco (SE coast) with the tiny rock Scoglio Bastimento.

Origin and evolution of a volcanic archipelago

The Aeolian Archipelago belongs to the category of "thalassogenic" islands, whose origin took place in total autonomy from the surrounding lands, unlike the "chersogenic" ones that originated through gradual isolation from the mainland (e.g., as a result of rising sea levels). However, the emersion of the Aeolian Islands is closely related to the geological events that, since the Late Oligocene (25 million years ago), gave rise to the formation of the Apennine chain and the opening of the Tyrrhenian basin, and is the result of subduction processes linked to the convergence of the African and Eurasian plates.

The Aeolian Islands are the emerged portions of a larger volcanic system of semi-anular shape, which to the west and northeast of the archipelago also includes several sea mounts (see the map below) and in the central sector is crossed by a major regional tectonic discontinuity line. This system is set on a continental-type crust arranged along the western and northern margins of the basement of the Calabro-Peloritanian Arc, which is thicker (up to 25 km) in the direction of Calabria, while thinning in the abyssal plain of the Tyrrhenian Sea. The magmatic activity of the Aeolian volcanic "arc" – with few exceptions – has gradually migrated from West to East and experienced a progressive enrichment in potassium (from the oldest basaltic lavas to the latest shoshonitic products from Vulcano and Stromboli). These changes in magma composition are the result of the influence of fluid and sedimentary components co-occurring in the lithosphere involved in the process of plate subduction.

The volcanic activity in this area began more than a million years ago, but the islands were formed only during the last 300,000 years and some of them are relatively "young" (e.g., Alicudi, Stromboli, Vulcano). Even the oldest islands, however, have been affected by recent eruptive events, sometimes occurring after long stages of quiescence.

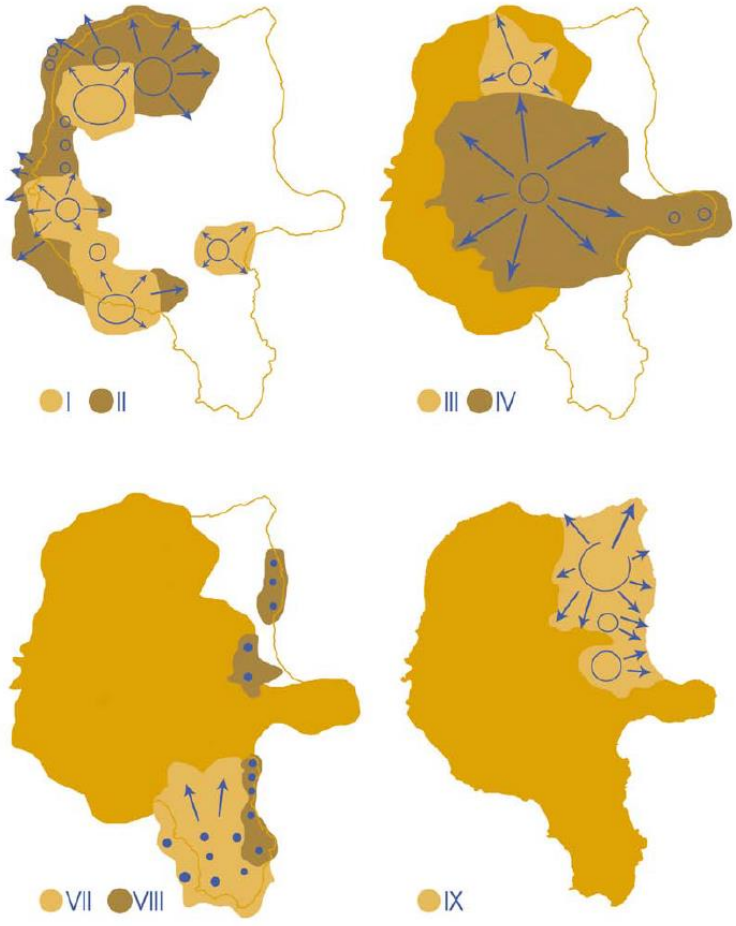
Currently, the main active volcanoes are Stromboli and La Fossa of Vulcano.

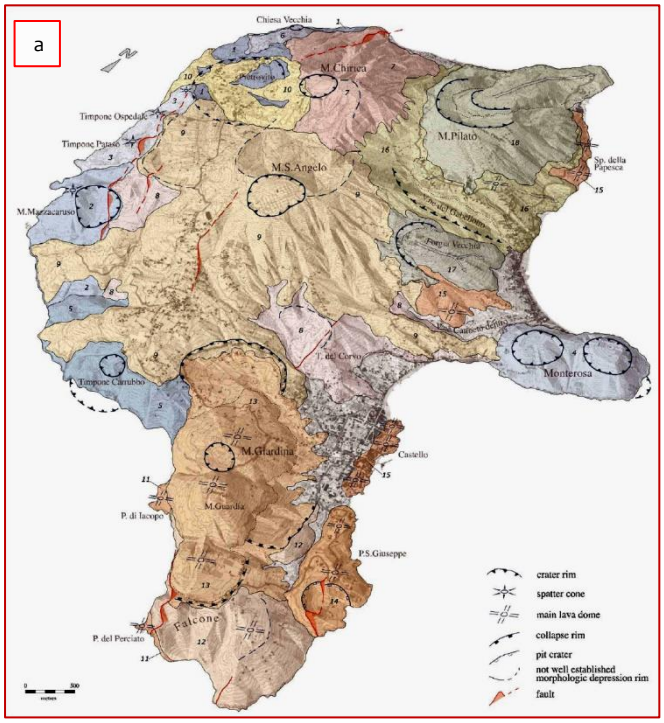
The last eruption of this latter occurred between 1888 and 1890, while Stromboli is characterized by constant activity, with eruptions at more or less regular intervals and occasional lava flows.

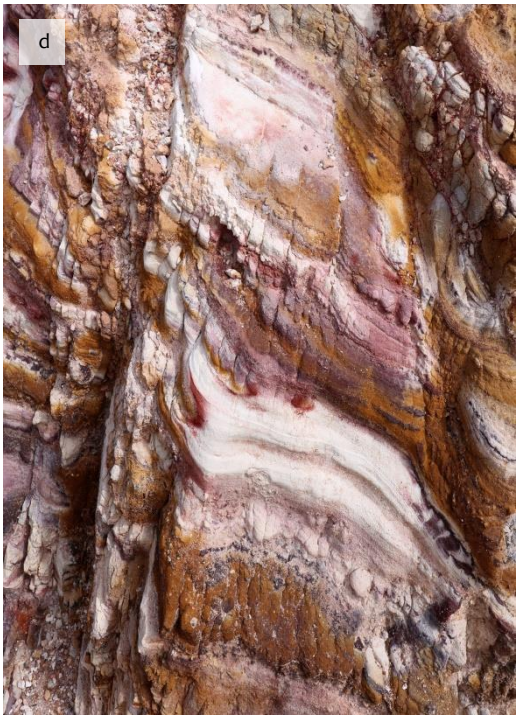
In 2002, paroxysmal episodes also occurred in the submarine crater off Panarea, awakening the attention of the scientists on the possible volcanic hazard. In almost all islands there are also phenomena of secondary volcanism, mostly consisting of fumarolic emissions.

Lipari

The island's morphology is dominated by the stratovolcanoes of Monte Chirica (602 m a.s.l.) and Monte Sant'Angelo (594 m), aligned in a north-south direction along the central sector. By contrast, the oldest volcanic products, dated around 270,000 years ago, are the lava flows and pyroclastites of the "timponi", a series of eruptive centres arranged along the western coast. According to the most recent data, the geological evolution of Lipari is divided into nine distinct eruptive epochs, interspersed with periods of quiescence during which intense erosional processes and some volcano-tectonic collapses occurred. The central epochs (between 120,000 and 80,000 years ago) were dominated by the activity of Monte Sant'Angelo, whose explosive eruptions produced large volumes of pyroclastic material.
Between 40,000 and 20,000 years ago, the southern and eastern parts were formed by the sub-plinian activity of the volcano of Monte Guardia and the formation of several domes (Falcone, Punta Perciato, Monte Giardina, Castello, Capo Rosso). The north-eastern sector, on the other hand, was affected by the pumice eruptions of Vallone Gabellotto and the Pomiciazzo lava flow (9,000 years ago), the formation of the cone of Monte Pilato and the Forgia Vecchia lava flow (776 AD), and, finally, the Rocche Rosse lava flow (1220 AD), which represents the last episode of volcanic activity on Lipari.
The island is currently in a quiescent state, but the presence of low-temperature fumaroles (80-90 °C) and hot springs indicates the persistence of a deep magmatic system.







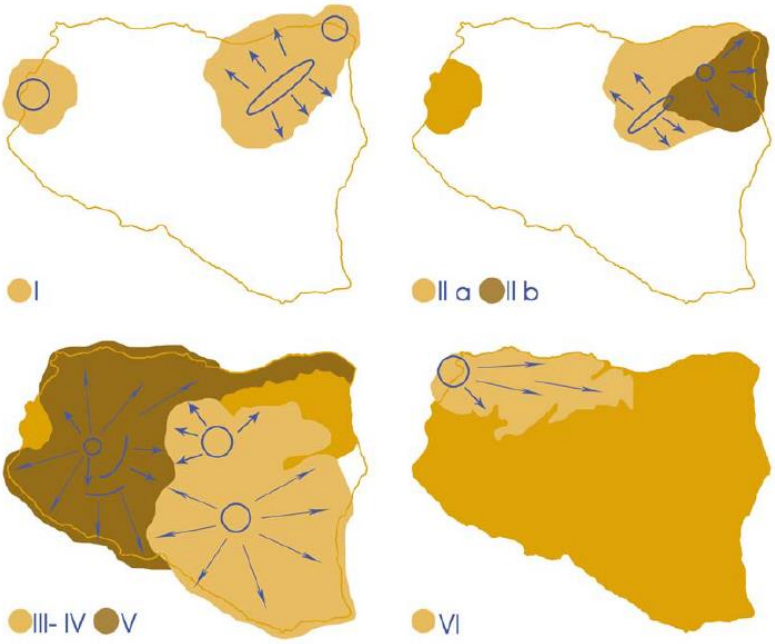
a) geological sketch of Lipari Island (courtesy of V. Cabianca), b) the palaeolake of Timpone Pataso (NW sector), c) fossil leaf of *Chamaerops humilis* from the palaeolake, d) fumarolized rocks at the kaolin quarries, e) the volcanic domes in the SE coast, f) the pumice quarries (NE sector) seen from Mount Pilato: mining exploitation ceased in 2007.

Salina

The conformation of the island, dominated morphologically by the presence of the stratocones of Monte dei Porri (in the western sector) and Monte Fossa delle Felci (in the south-eastern sector), has inspired the Greek name of Salina (Διδύμη = twin); the two mountains are separated by a saddle oriented in a north-south direction (Valdichiesa).

The process of formation of the island can be divided into six distinct eruptive epochs. The first is characterized by the activity of the two volcanic centres of Pizzo di Corvo (to the south-west) and Pizzo Capo (to the north-east); the age is still uncertain, but some volcanic products from Pizzo Capo are supposed to date back 244,000 years. Between 160,000 and 121,000 years ago, the formation of the Monte Rivi centre occurred, with the emission of basaltic lavas and a subsequent strombolian explosive phase, and that of Monte Fossa delle Felci, which was built up during four eruptive phases interspersed with as many periods of quiescence.

Since 63,000 years ago, the formation of the stratocone of Monte dei Porri (63,000-26,000 years ago) and that of the Pollara centre (30,000-13,000 years ago) took place in the western sector. The last hydromagmatic eruption of Pollara represents the last episode of volcanism on the island. The crater depression was occupied by a lake, later filled with sedimentary material whose section in nowadays evident on the west-facing cliff.



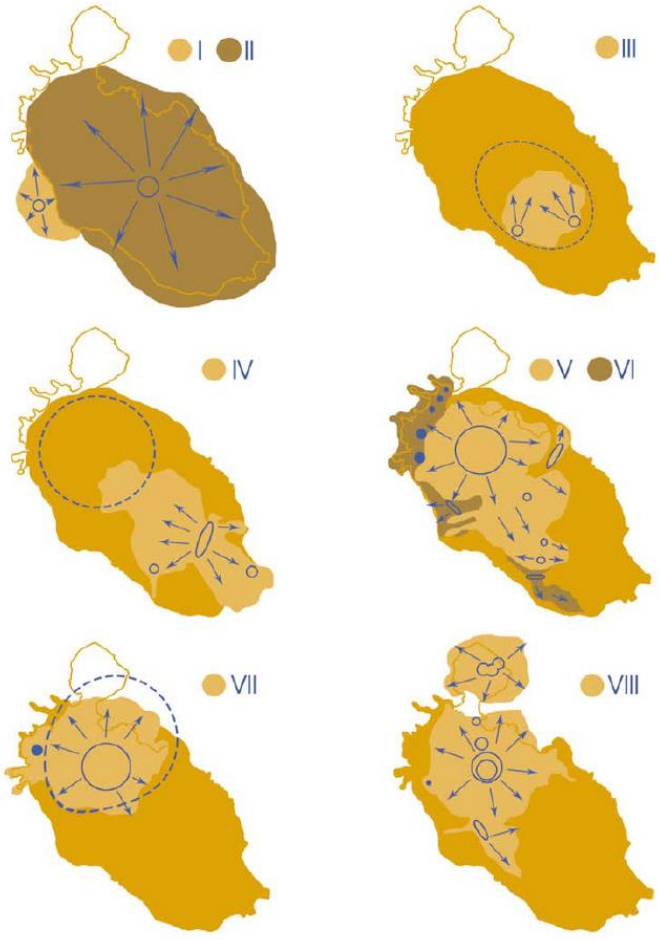
Scoglio Faraglione Islet and the cliffs of Pollara

Vulcano

Together with Lipari and Salina, Vulcano forms a single structural complex – mostly submerged –that runs in a NNW-SSE direction, parallel to the ETLM (Aeolian-Tindari-Letojanni-Malta) regional tectonic line. The geomorphological structure of the island is rather articulated, due to the superposition and succession over time of a large number of volcanic and volcano-tectonic events, which occurred within eight distinct eruptive epochs. The first of these, whose products are visible between Spiaggia Lunga and Punta del Rosario, began 127,000 years ago in a submerged centre located near Capo Secco, just off the west coast.

Since 117,000 years ago, several massive lava flows and thick scoria deposits build up the "Primordial Volcano", which forms most of the central-southern portion of the island. Around 100,000 years ago, the top of this stratocone was demolished by a volcano-tectonic collapse, forming a wide caldera (Piano) successively filled by the products of secondary centres located along its margins.

Then the activity shifted northwards, with the formation of a tuff cone in correspondence to the current position of La Fossa volcano, which was characterized by hydromagmatic eruptions (70,000-42,000 years ago). Other activecentres were located at Monte Lentia (28,000-21,000 years ago) and near La Fossa (20,000 -13,000 years ago). The activity at Monte Lentia continued with the effusive flows with trachytic-riolitic composition that originated the endogenous domes, some of them stretched out over the sea giving rise to the pictoresque finger-shaped promontories of the north-west coast.



The last eruptive epoch is characterized by the formation of Monte Saraceno (8,000 years ago) and the present-day cone La Fossa (from 5,500 years ago), which is mainly built up through hydromagmatic eruptions within the caldera formed by the volcano-tectonic collapses of pre-existing centres. Another centre was active at the Faraglione di Porto Levante, which represents the remains of a volcanic outcrop intensely eroded by hydrothermalization. The latest episodes affecting La Fossa are the flow of obsidian-rich rhyolites (1739), locally known as "Pietre Cotte", and the strong eruption between 1888 and 1890.

Vulcanello is the northern tip of the island and was formed from an initially separate centre, merged with Vulcano since the 16th century through the formation of a sandy isthmus. Chronicles reported by Pliny the Elder and Strabo mention volcanic activity in the channel between Lipari and Vulcano as early as 126 or 183 BC. However, recent archaeomagnetic data indicate for Vulcanello an age of just 1000 years. The last eruption of this centre occurred in 1626, while fumarolic activity continued until 1878.

a) fumaroles along the rim of La Fossa crater, b) a «bread crust» bomb ejected during the eruption of 1888-1890, c) another volcanic bomb fallen in the plain currently hosting the village of Vulcano Porto (from Bergeat, 1900).

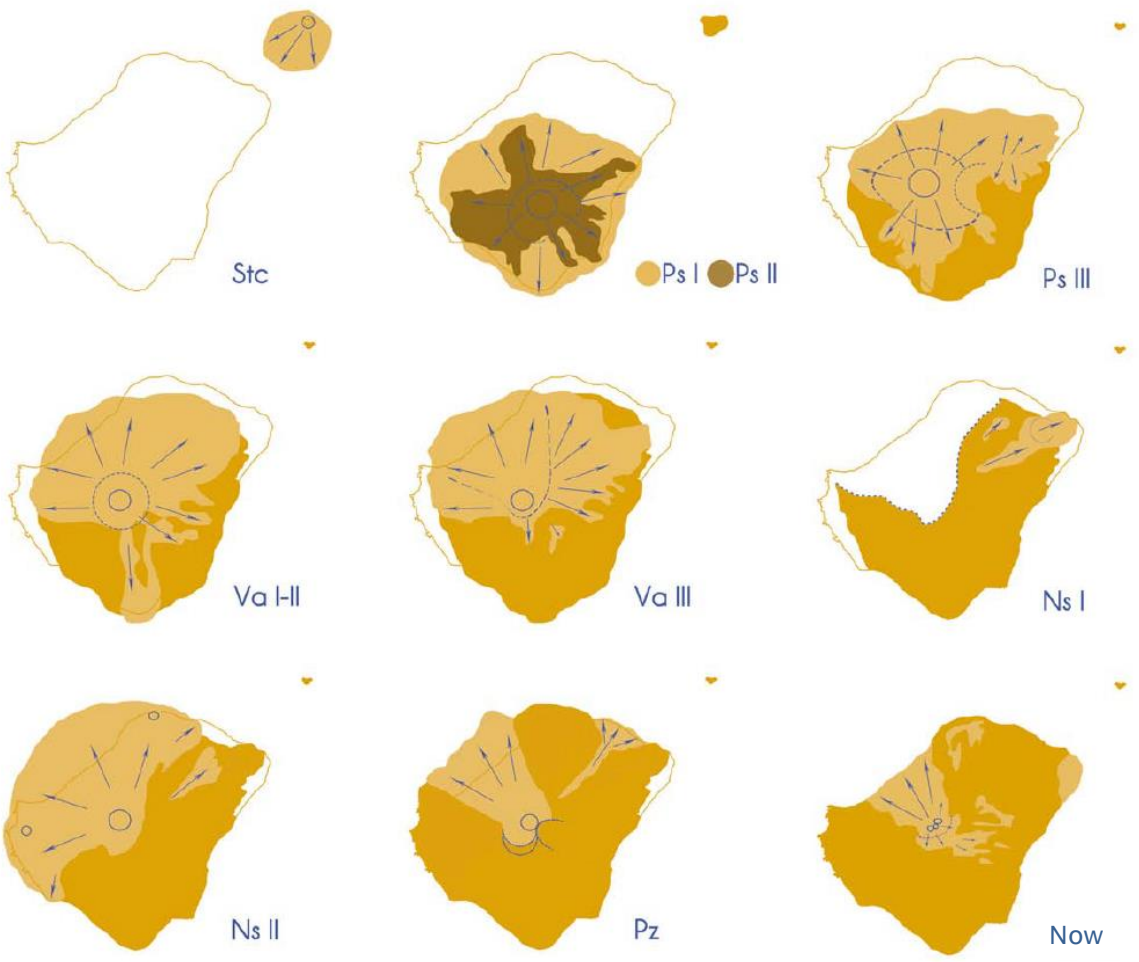
Stromboli

The volcanic building of Stromboli extends for more than 20 km along the regional tectonic line that dominates the eastern sector of the archipelago and for about 3,000 m in total height, 2/3 of which is submerged, where the flanks descend to the Tyrrhenian Sea floor with an average inclination of 20-25°. It is therefore a volcano of huge dimensions, whose geological evolution – at least for its emerged portions – has been completed over the last 205,000 years. Indeed, this is the age attributed to the products of the oldest eruptive centre, that of Strombolicchio, a tiny islet off the North-East coast of the main island, now largely dismantled by erosion.

Bathymetry around Stromboli, from Bosman et alii 2009 (left) and the neck of Strombolicchio (right).

Around 85,000 years ago the basal portion of a stratocone named the "Paleo-Stromboli 1", started to form; its andesitic lavas outcrop in the southern sector of the island. Slightly more recent are the products forming the "Petrazza tuffs", belonging to an explosive phase that originated pyroclastic currents and deposits, with thicknesses of up to 70 m. The summit portion of Paleo-Stromboli 1, which probably reached 400 m a.s.l., was finally destroyed by a caldera collapse.

Between 65,000 and 35,000 years ago, two main eruptions formed the "Paleo-Stromboli 2", built by lava flows and tephra that overlapped the pre-existing caldera, reaching 700 m a.s.l.; this latter underwent too collapse events, both in the top (with a calderic rim still visible at Frontone) and in the eastern slope (collapse of the Schicciole sector). After a period of dormancy, the highest part of the island was affected by the activity of the Vancori eruptive centre, which was built up during three distinct phases – the "lower" (dating back 26,000 years), "medium" (21,000 yrs) and "upper" (13,000 yrs) – and followed by a series of collapses that greatly affected Stromboli's activity: the first of them dismantled a portion of the NW flank, incising the main eruptive vent. About 13,000 years ago, on the remains of the Vancori and in the area of Pizzo Sopra la Fossa, the activity of the "Neo-Stromboli" began, contemporaneously to that of the secondary centres of Timpone del Fuoco (north of Ginostra), Punta Labronzo and Nel Cannestrà (behind Ficogrande). A new collapse of its summit portion formed the Sciara del Fuoco ("Recent Stromboli"), a steep slope shaped during the last 5,000 years through repeated concentric collapses. During the same period was also active the San Bartolo centre (behind the town), which produced the massive andesitic-basaltic lava flow that about 2,000 years ago has reached the sea in the coastal sector of Piscità.



Stc) Strombolicchio, Ps) Paleo-Stromboli, Va) Vancori, Ns) Neo-Stromboli, Pz) Pizzo

The present craters are located at the summit of the Sciara del Fuoco (about 750 m a.s.l.), thus lower than the highest peak on the island (the Vancori, 924 m a.s.l.), and – although they undergo periodic changes over time – their activity has remained essentially unchanged over the past few thousand years. The characteristic eruptive style – called "Strombolian" – consists of a rhythmic succession of low-energy explosions, with the launching of shreds of lava and slag: this is brought about by the coalescence of large bubbles of gas – initially dissolved in the magma – that rise faster than the latter, exerting a pressure capable of overcoming its cohesive force and causing its fragmentation. The trajectory of such explosions generally does not exceed 100-150 meters in height over the craters, and the volume of ejected material is rather limited. Stromboli, however, is periodically affected by explosive eruptions of greater intensity: the most dramatic during the last century was with no doubt that of 1930, but – still just a few years ago – other paroxysmal episodes, with emission of ash, bombs, and lapilli, have caused extensive fires also in the slopes occupied by the villages.

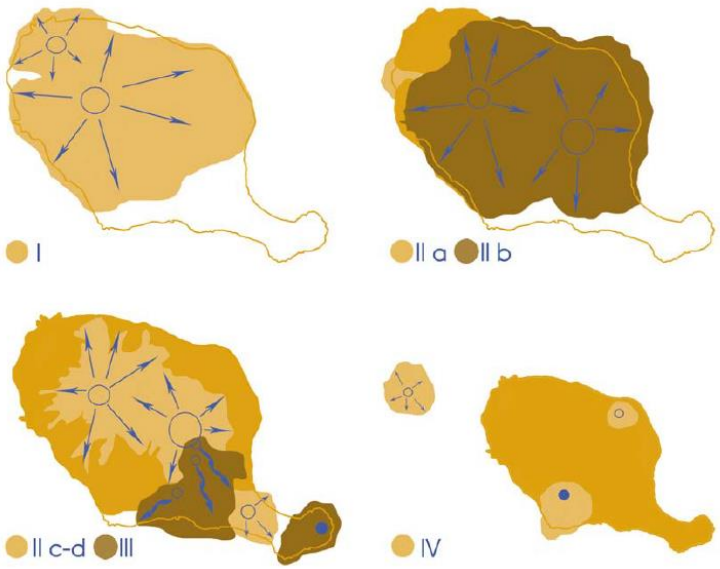
Instead, the eruptive fractures that open sometimes on the Sciara del Fuoco can produce lava flows, reducing the explosive activity of the summit craters. One of them, occurred in December 2002, generated a strong accumulation of material and the subsequent detachment of a landslide of more than 30 million m^3 in the submerged sector that originated a tsunami wave, causing damage to homes but fortunately with no fatalities.

a) the top of Stromboli, b) typical «strombolian» activity, c) lava tunnel on the Sciara del Fuoco after the lava flow of 2014, d) lava flow on the Sciara del Fuoco, 2002, e) basaltic lavas on the cliffs of Strombolicchio Islet: the oldest products of the volcanic apparatus of Stromboli.

Filicudi

During the last few years, the reconstruction of the geological evolution of Filicudi and especially the age estimated for its volcanic products have undergone substantial revisions; according to the most recent data, the island has been formed from 246,000 years ago during four distinct eruptive epochs, whereas previous dating had indicated an age of 400,000 or, even, more than 1,000,000 years.
The oldest products have been identified in the north-western sector, at an eruptive centre at Case Ficarrisi, and are interpreted as the initial stage of the formation of the polygenic volcano of Fossa Felci. These lavas have a predominantly basaltic composition and occur with scoria deposits formed during phases of "strombolian" activity.
The second eruptive epoch – since 225,000 years ago – is characterized by the formation of the twin stratocones of Chiumento and Fossa Felci, in the central sector of the island. Lava flows and scoriaceous deposits alternate with periods of (sometime long) quiescence. The formation of the scoria cones of Riberosse, close to Fossa Felci, and Monte Guardia, which is built on the SE slope of the Chiumento stratocone in a more isolated position, occurred also during this phase.
The third eruptive epoch began with a sector collapse that involved the Chiumento stratocone, giving rise to the formation of the wide depression of Valle Chiesa; on the SE rim of this latter, a succession of lava flows with andesitic composition built the centre of Monte Terrione, while around 146,000 years ago the formation of the andesitic-dacitic dome of Capo Graziano, representing the south-eastern edge of the island, occurred.
After a long period of dormancy, from 64,000 years ago a new phase of volcanic activity involved both the central-southern and the northern sectors, forming respectively the Monte Montagnola and Zucco Grande, whose pyroclastic deposits are the island's most recent products.
A now largely dismantled eruptive centre is instead located west of Filicudi. La Canna stack and the surrounding rocks represent its still-emerging remains. It was initially attributed to the first phase of the island's formation, since the lavas are of basaltic or basaltic-andesitic composition. Recent radiometric dating, however, has indicated for La Canna – which represents a typical example of a volcanic neck – an age of "only" 29,000 years, overturning the previously proposed chronological framework and placing it as the conclusive episode of Filicudi's eruptive history.


La Canna

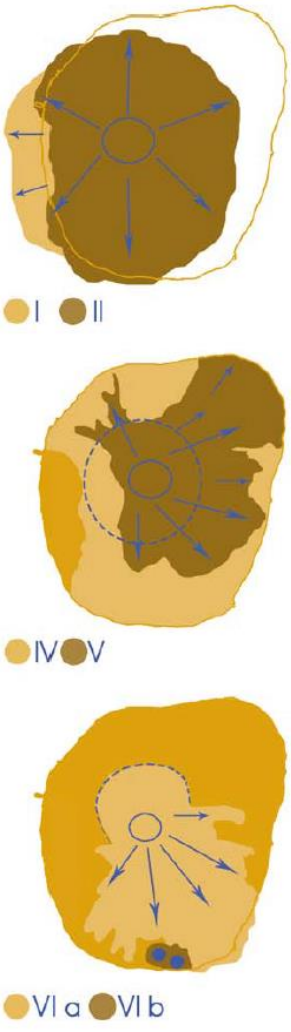


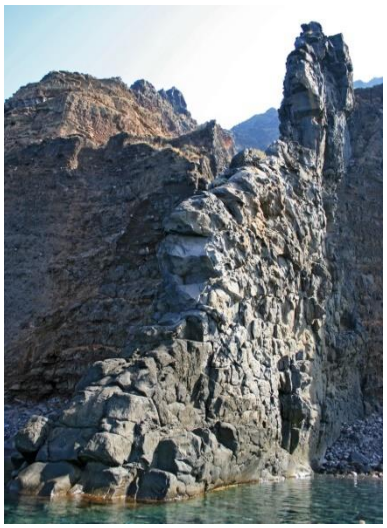
Alicudi

Alicudi represents the subaerial portion of a stratovolcano whose basal diameter extends for about 15 km and which spreads from bottoms of -1,400 m. During the different phases of its formation, the volcanic vents did not undergo the "migration" along the NW-SE direction that is typical for many other Aeolian volcanoes: this suggests that its evolution must have been only marginally affected by regional tectonics.

The morphology of the island is characterized by significant differences between the eastern and southern sectors, whose slopes show a constant inclination of 25-30°, and the northern and western ones, which have steep slopes as a result of intense erosive processes. All the island is also characterized by the occurrence of basaltic dykes, arranged radially with respect to the volcanic building, which are the result of surface deformations produced by the rising magma during various eruptions.

The eruptive history of Alicudi is divided into six distinct epochs. The oldest products, dating back to 106,000 years ago, are represented by the basaltic and basaltic-andesitic lavas of a stratocone (Paleo-Alicudi) outcropping at the base of the western coastal cliffs near Scoglio Galera. After a short period of dormancy, the volcanic activity re-started with the formation of another stratocone, whose crater must have been located at 600 m a.s.l., characterized by effusive phases alternating with "strombolian" explosions and affected by partial collapses. The following two eruptive epochs are characterized by the overlap of welded slag cones (spatter cones) with hawaiian-strombolian-type activity, later dismantled by volcano-tectonic collapses on their top. In particular, the fourth epoch (80.000 years ago) corresponds to the build-up of most part of the island: initially, large volumes of volcanic products – mainly andesitic – filled the caldera, while the formation of the endogenous dome that outcrops to the north of Dirittusu occurred; successively, the outpouring of dome-flow took place – a dome that tended to flow downwards along the slopes of the Dirittusu sector.



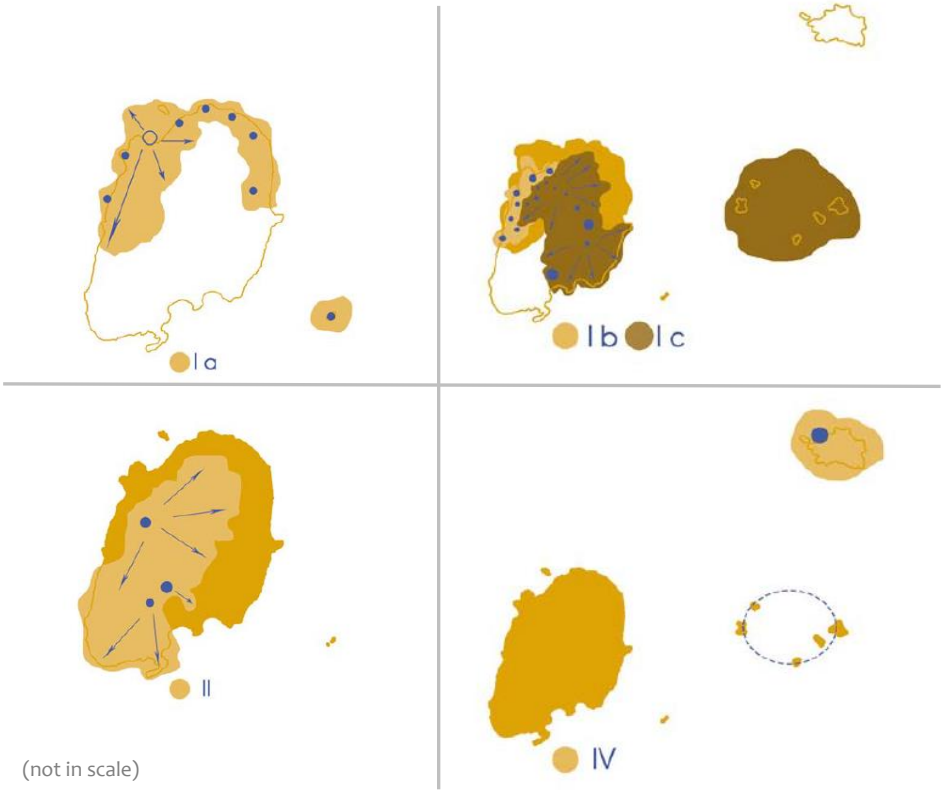


Here, finally, the last volcano-tectonic collapse occurred, forming the summit plateau. Between 60,000 and 32,000 years ago, some eruptive centres near the summit domes originated a succession of andesitic lava flows along the eastern and north-eastern flanks, that reached the coast between Porto and Spano (north of Bazzina); another lava flow also affected the north-western sector, at Punta di Malopasso. The last episodes of Alicudi's eruptive history, occurred around 28,000 years ago, led to the formation of the endogenous domes of Montagnole and Filo dell'Arpa, corresponding to the highest point of the island, and the emission of andesitic lava flows along the southern flank of the island.

Basaltic dyke near Scoglio Galera, W coast of Alicudi.

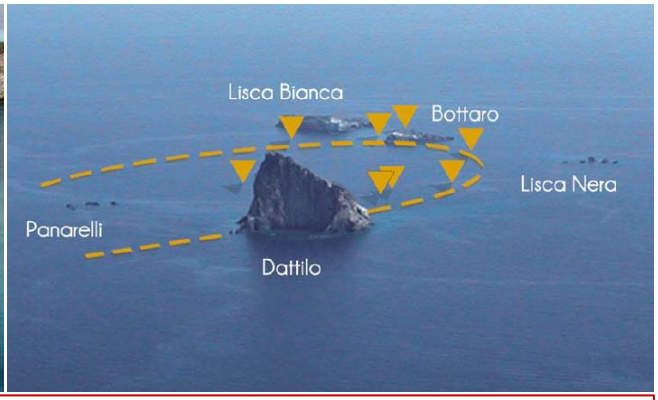
Panarea

Panarea and its satellite islets are the emerged portions of a large volcanic edifice (18 km in diameter) that rises from -1,700 m. Together with Stromboli, it is arranged along a NE-SW-oriented regional tectonic system and has undergone a considerable vertical uplift, evidenced by the presence of a Tyrrhenian marine terrace (dated 124,000 years ago) at 115 m a.s.l. (the highest elevation found in the archipelago). The island does not present the typical truncated-cone shape of volcanic buildings since it was built up mainly by the overlap of several lava domes, the oldest of which were formed during the first eruptive epoch (starting 155,000 years ago) in correspondence of the northern and western coast (Grotta del Tabacco and Punta Scritta), interspersed with pyroclastic deposits. The formation of Le Formiche (now almost entirely submerged) probably also dates back to that epoch.



Around 132,000 years ago, the activity involved the central and southern part of Panarea, with the formation of the domes and lava flows of Palisi, the endogenous dome of La Fossa, and the two characteristic plug domes of Punta Falcone and Punta del Tribunale. Between 134,000 and 130. 000 years ago, another volcanic centre – perhaps a crater, or a dome field – was active in correspondence of the submarine morphological depression around which are located the islets of Dattilo, Lisca Bianca, Bottaro, Lisca Nera and the Panarelli rocks. The products of this centre, mainly andesitic and dacitic lavas, have been strongly altered by hydrothermal activity, as revealed by the massive occurrence of vividly coloured kaolin deposits, and are subject to intense meteo-marine erosion. During the second eruptive epoch (124,000-118,000 years ago), the top and the southern part of the island were involved in the formation of the dome of Castello, the dome-flow of Punta del Corvo, and a phase of strombolian explosive activity with pyroclastic, pumice and scoria deposits in the area of Soldata.

The third eruptive epoch (around 100,000 years ago) was characterized by the activity of a centre – probably located in the islets area – whose scoriacieous products were discontinuously deposited over the island, especially in the Punta Falcone area.
After a long period of quiescence, the last eruptive epoch was characterized by the formation of the endogenous rhyolitic dome of Basiluzzo (54,000 years ago); in addition, one or more centres were still active around 24,000 years ago in the islets area, with strombolian-type explosions that originated the pumiceous deposits of Drauto.
Panarea is still home to secondary volcanic activityin the fumarolic field in the Calcara beach, with constant temperatures around 100 °C. Gas emission of hydrothermal origin mainly consist of water vapor (93-98%) and carbon dioxide (2-6%), along with smaller amounts of hydrogen sulphide, nitrogen, methane, hydrogen, argon, helium, neon, and heterocyclic compounds.
A larger fumarolic field (about 2 km^2 of surface) occurs underwater near the islets, with about 20 points of gaseous emission, acidic hot springs with temperatures up to 155 °C, and a widespread exhalation largely affecting the seabed. In November 2002, several explosions formed new fumaroles (and increased the existing ones) near Bottaro, characterized by flows of considerable intensity (estimated at around one billion litres per day) and by significant amounts of soluble acid gases – hydrochloric acid, hydrofluoric acid, sulphur dioxide – typical of magmatic outgassing processes of an active volcanic system, which induced dramatic alterations in the nearby submarine biocoenoses. The related monitoring activities have revealed important spatio-temporal changes in terms of physical (gas flow intensity, temperature) and chemical properties, confirming that the volcano is still active and that its magmatic fluids interact with the more superficial hydrothermal system.



Above: massive submarine gas emissions near Bottaro, November 2002 (left); the fumarolic submarine area with the main points of gas emissions near the islets (right). Below: the islets of Bottaro and Dattilo and Panarea Island on the background, seen from Lisca Bianca (left); the islet of Lisca Bianca: the white colour of the cliffs are due to the alteration produced by the hydrothermal activity.

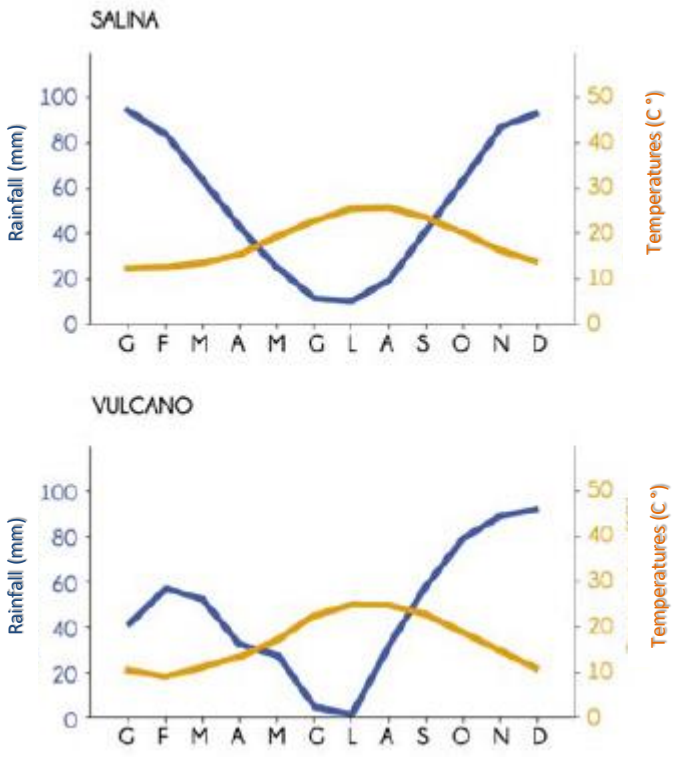
Climate and hydrography

At first glance the Aeolian Islands may appear to be a homogeneous territory from a climatic point of view, but several factors – such as altitude, distance from the sea, aspect and slope – determine significant differences between the islands, as well as the co-occurrence of different micro-climates within each island.

In general, rainfall is mainly concentrated in the autumn and winter months and reaches annual values between 502 and 668 mm, which can vary over the years with fluctuations of 50% in either direction. Average annual temperatures are around 18 °C, with a thermal excursion of about 13 °C.

However, when comparing rainfall and temperature data recorded at the weather stations of Vulcano Piano (420 m a.s.l.) and Santa Marina of Salina (35 m a.s.l.), there are some differences: the latter – located at a low altitude but influenced by the island's orographic conformation – is characterized by higher annual averages; the average annual temperature at Salina (18.4 °C) also differs significantly from that recorded at Stromboli (14.4 °C), where the station is located over 700 m a.s.l.

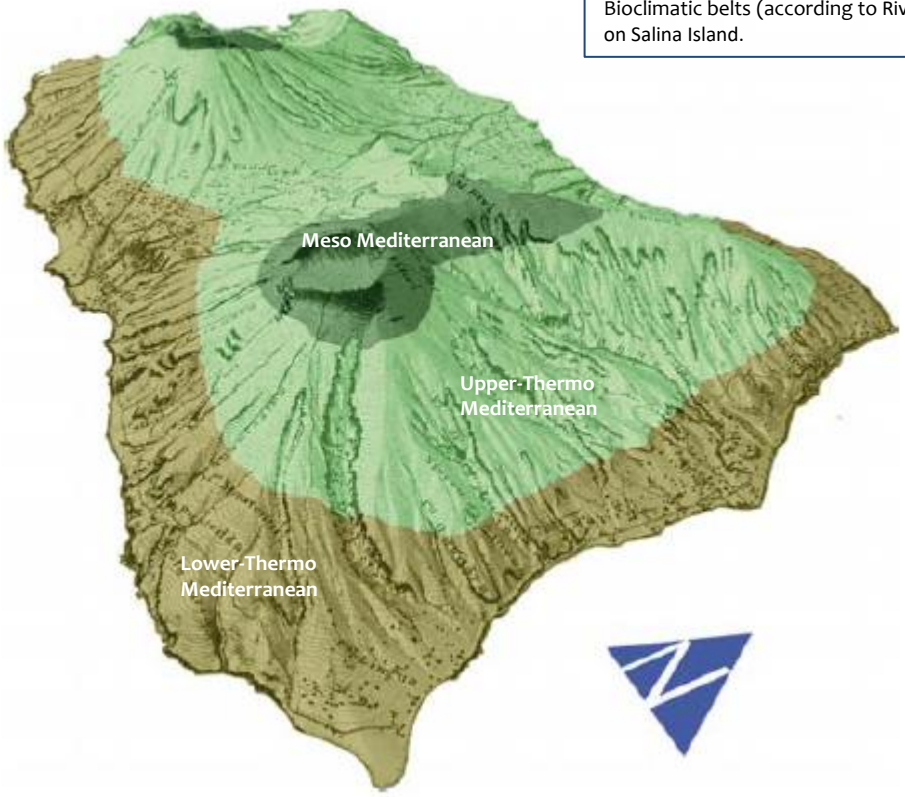
As can be expected in small islands surrounded by the sea, the values of relative humidity are quite high: in summer, in particular, they hover around 50% during the hottest and sunniest daytime hours, while humidity has a considerable increase (even over 90%) at night, especially when there is high pressure and subsidence of humid air occurs when wind is absent (vapor condensation in the form of dew). This phenomenon plays an important role in ecological terms, as it produces intense overnight dew accumulation providing a key water input to local vegetation during the driest months.



The predominant winds come from West and North-West. In 61% of cases, storms are originated by winds from the western quadrants, while only 21% of cases are from the South-East.

According to the classification proposed by Rivas-Martínez, based on the definition of thermotypes and ombrotypes respectively obtained from the annual averages of temperature and precipitation, the islands lie mainly in the Upper Thermo-Mediterranean thermotype and with Upper Dry ombrotype; exceptions are the south-facing coastal slopes, referred to the Lower Thermo-Mediterranean thermotype and Lower Subhumid ombrotype, and the highest reliefs, which fall in the Upper Thermo-Mediterranean thermotype and Lower Subhumid ombrotype.

Only the top of Salina, which is close to 1,000 m a.s.l., is subject to Meso-Mediterranean bioclimatic conditions which support mature and well-structured forest formations.



Bioclimatic belts (according to Rivas-Martínez) on Salina Island.

There are several thermal springs on the islands, while the freshwater ones are rare and seem to have undergone a substantial reduction over the past 150 years: some small pools into few cavities at Vallone Fontana (Filicudi), and trickles in the islands of Lipari, Salina, Vulcano and Stromboli. An interesting wet habitat formed by small temporary ponds at Monte S. Angelo (Lipari), still existing in late 19th century, have now disappeared.

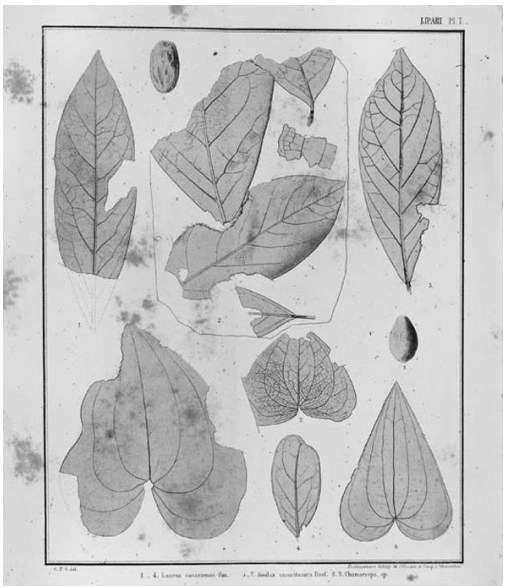
A small cave pool at Vallone Fontana, Filicudi (above), and a seasonal stream formed by the spring of Vallone Fuardo, Lipari (left).

From agriculture to tourism: landscape and communities

To have an idea of the pristine landscape of the Aeolian Islands, it could be enough to have a look over the Sciara del Fuoco at Stromboli, or the arid sandy slopes of La Fossa crater at Vulcano. Just few tens of thousands of years ago, in fact, active volcanoes occurred in almost all the islands.
Their effects were often felt on a large scale: tephritic and pyroclastic deposits of relatively recent origin – such as brown tuff from the last eruptive phases of Vulcano, or pumice from Monte Pilato crater on Lipari – are widely distributed throughout the archipelago, even on islands farther from their sources, and represent important chronological markers for the stratigraphic investigations.
A gradual diminution of the eruptive events – which during the last 10,000 years have been concentrated exclusively in the north-eastern sector of Lipari, the northern sector of Vulcano and at Stromboli – has certainly favoured the expansion of more stable plant communities, which however occurred also in past (although subject to periodic fluctuations and contractions due to natural disturbance), as testified by the plant fossil remains found in several sites of the archipelago.

A glance to the past: fossil plants and tortoises

About 100,000 years ago, a lake occupied a small area near the volcanic centre of Timpone Pataso, in the western side of Lipari. This basin was gradually filled by pyroclastic materials deposited during the eruption of the volcano of Monte Sant'Angelo. The stratigraphy shows an alternance between primary and secondary layers, produced by sin-depositional remobilisation processes. These latters include remains of the plants growing along the shore of the lake.
Three woody species have been found: the endemic *Cytisus aeolicus*, *Laurus nobilis* and *Chamaerops humilis*, the only species still persisting in the area. The laurel occurs now in the island only as cultivated plant, and its extinction from the native flora could be related to the climate changes occurred during the last 100,000 years, especially to the dry and cold period corresponding to the last pleistocenic glaciation.
Other plant remains have been found at Piano (Vulcano), Pollara (Salina) and Fossa Valle (Lipari). From this latter, a radiometric dating indicates an age limit of > 20,000 years, which corresponds to the Würm glaciation. Several remains of a pine species were tentatively identified as belonging to the black pine group (*Pinus nigra*).
During the enlargement of a road in Valle Pera (NW Lipari) fossilized remains of *Testudo hermanni* have been found from pyroclastic layers dating back about 40,000 years ago. So far it is the only fossil record of Vertebrates found in the archipelago.



Some fossil leaves from a 19th-century contribution to the palaeo-flora of Lipari (Gaudin & Pirajno di Mandralisca, 1860).

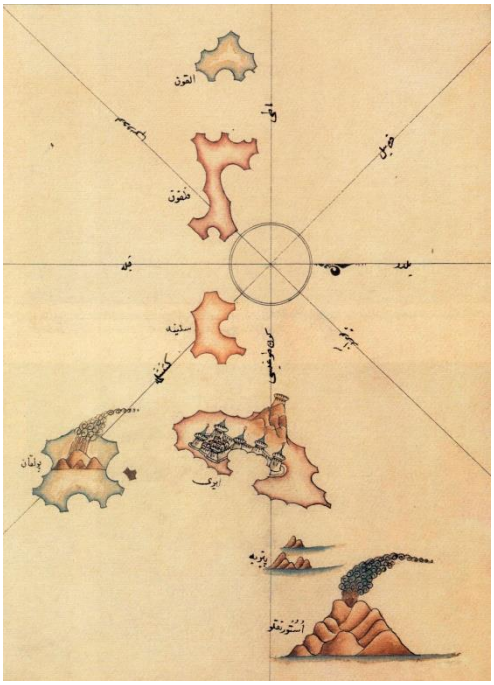
Fossilized cone of *Pinus* gr. *nigra*.

The end of a millenary agricultural civilisation

During the last 8,000 years, the landscape of the Aeolian Islands has been shaped primarily by humans. Since the earliest settlements (middle of the 6th millennium BC), agriculture represented in fact the main resource for the inhabitants, while the sea represented a way of connection between the islands and the outside world or, alternatively, an isolation constrain. The human presence was relatively constant through time, except for a slight decline only between the 11th and 5th centuries B.C. and again between the 6th and 11th centuries A.D.; even during the first phase of colonization, strictly related to the exploitation and the trade of obsidian, the villages were placed near the most suitable places for farming, such as the large plain of Castellaro at Lipari.

With no doubt, such rural activities induced major transformations of the landscape: today it is almost impossible to see a place on the islands – including those far from urbanized areas – where there are no direct or indirect signs of anthropogenic activity.

However, it is difficult to quantify the extent of the transformations that occurred during the prehistory, as well as in Greek and Roman times. In contrast, more recent ones (particularly between the 17th and 19th centuries) are very evident, especially on some islands where – within the limits imposed by geomorphology – human activities have affected almost the whole territory as a direct consequence of rapid population growth.



The Aeolian Islands in a map drawn by the Arab geographer Al-Idrisi (XI-XII century AD).

The islands – where flat areas are rare and generally small – have been cleared and converted into terraced systems for agriculture exploitation. According to a study published by ARPA in 2009, three of the four Aeolian municipalities (Lipari, Malfa and Santa Marina) have the highest rate of terraced surfaces at the regional scale (more than 30% of the total); the terraced agricultural systems in the archipelago cover about 39 km^2, and are widely represented in Alicudi, Filicudi and Panarea.

In 1870, crops occupied 30% of the surface of Lipari, 41% of Salina and even 51% of Filicudi. Only Vulcano – basically uninhabited until the 20th century – was an exception, with a cultivated area of 0.2% of the total. Concerning the islands included in the municipality of Lipari, the land register of 1870 reported 1,240 hectares of vineyards, 2,584 of pasturelands and 860 of cropland, while 812 were occupied by "woods", a definition that probably included also shrubland.

Especially during the second half of the 19th century, agriculture was largely oriented as a monoculture, justified by the fact that vineyards provided the top exportable products – wine, malvasia and "passolina" (dried grape) – and thus represented the most profitable crop. At the end of this century, farmers were 41% of the local workers, while only 10% were fishermen and seafarers. When the islands were invaded by phylloxera (*Daktulosphaira vitifoliae*) – a North American parasite that attacks the root system of European grapevines – the impact on the local economy was dramatic, triggering a crisis that caused dramatic depopulation within a few decades and the disaggregation of the smaller communities of the peripheral islands.

These socio-economic events had significant effects also on the Aeolian landscape: 90% of the terraces have been abandoned about one century ago. Currently, the dry-stone walls are almost everywhere subject to collapse, and in the forthcoming decades erosive processes will probably transform the slopes of some islands into vast, desolate stony grounds, with dramatic ecological, hydrogeological and – not least – cultural consequences.
The recovery of these terraces is challenging, also because land ownership is often divided among dozens of heirs, descendants of the islanders who migrated to Australia or other non-European countries between the late 19th century and the first half of the 20th century.

Surroundings of Lipari town and Filicudi (Porto and Capo Graziano) were extensively cultivated in early XX century.

Land use and houses on Basiluzzo Islet in a map drawn by Giovanni Ottone di Berger (late 18th century); the same islet currently hosts only a house and abandoned terraces.

«Le Pianure», a flat area on the top of Alicudi, were used for the cultivation of cereals until the half of 20th century.

Agrobiodiversity

The traces of the millennial relationship established between humans and the Aeolian islands can be recognized not only in the terraced systems, but also in the local agricultural practices and crop selection processes; the heritage of varieties - undoubtedly the most relevant product of the latter - is the result of long efforts to obtain the most suitable characteristics (in terms of adaptation to local natural stress factors, productivity and food quality) and represents one of the most interesting expressions of the rural identity and culture of these islands.

In the late 1990s, researchers from the CNR-IGV of Bari and the Institut für Pflanzengenetik of Gatersleben attempted to take a census of the varieties of agricultural interest in the Aeolian Islands, or at least what was left of them after nearly a century of agricultural abandonment. The broad beans from Vulcano, flat-seeded peas (called "a carrubbo") from Salina, and the long-storage tomatoes ("siccagni") – which tolerate water deficit and are assembled in clusters ("piennuli") to be eaten in winter – belong to local ecotypes. These supposed ancient forms are now almost everywhere supplanted by standard cultivars: for example, Punta Bandiera (on the island of Vulcano) was renowned for producing a particular type of bean, but researchers have been unable to find it again.

Fruit trees, too, must have included numerous local forms, if it is true that – according to data reported by Archduke Ludwig Salvator Habsburg Lothringen – there were more than 25,000 fruit tree individuals only in Lipari at the end of the 19th century. Some of them – such as a variety of European plum (*Prunus domestica*) locally known as "pruna nuciddu" – are still quite widespread; however, most seem to have been lost or survive with very few individuals.

A similar fate has befallen the zootechnical heritage: no one today remembers anymore the pig of "*Turkish or Lipari race*" which was described as follows in 1868 by the Sicilian physician and naturalist Francesco Minà-Palumbo: "*setole riccie, di color fulvo, o giallo ruginoso, di raro bruno o nero, talvolta è di un giallo-dorato … i porcellini sono listati, come quelli del cignale. È di piccola statura … ma ingrassa bene a trenta mesi. L'ho veduto in Cefalù, si alleva in Lipari*" [curly bristles, tawny or wrinkled yellow, rarely brown or black, sometimes golden-yellow … the piglets are listate, like those of the wild boar. It is small in size [...] but fattens well at thirty months. I have seen it in Cefalù, it is bred in Lipari]. The decline of local varietal heritage mirrors a broader process of cultural erosion, which in just a few decades is erasing traditions and knowledge acquired over dozens of generations.

Some local varieties of fruit trees: «pruna nuciddu» (flowers), «pircuopu majulinu», «piru 'mbriacu», «piru cucuzzaru», «puma sarvaggiu», «piersicu jancu».

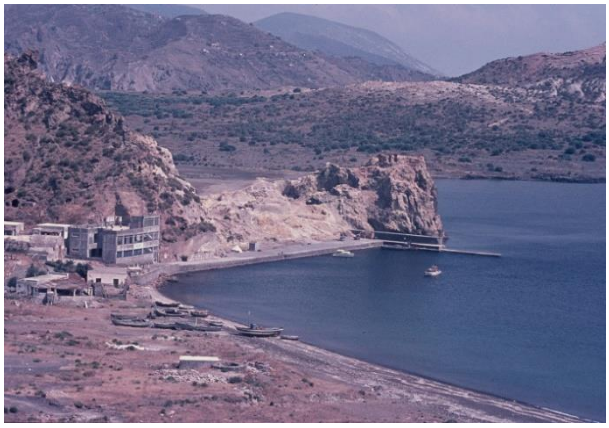
Tourism as new economic driver

During the 20th century, one of the most unique paradoxes in the history of the Aeolian Islands occurred: in the meantime that local farmers started to migrate due to the agricultural crisis, the islands began to be discovered as a tourist destination, a vocation that will profoundly change the socio-economic and cultural structure of local communities.

The beginning of this new course can be placed around 1950s, when the French association Connaissance du Monde organized the first "Croisière des volcans", inspired by documentaries made by the famous volcanologist Haroun Tazieff on Stromboli and Etna.

Since the first decade after the 2nd war, the archipelago became one of the tourist destinations that Corda Fratres, CAI, TCI and other organizations offered to university students and researchers. These were still timid initiatives, proportionate to a modest offer of accommodation facilities: in fact, in 1950 the total availability amounted to only 35 beds; four years later, these became 150 (distributed in 17 hotels) and the visitors were already around 11,400, 70% of them only at Stromboli.

In the 1960s, in parallel with the Italian economic boom, tourism acquired a new dimension: new hotels opened, mainly on Lipari – endowed with more services and infrastructure – and on Vulcano, where in the plain of the Porto – still not urbanized – building took place without any constraints. In 1966, these two islands had 16,840 and 8,150 visitors respectively (accounting for 72% of the total number of visitors), while the number of beds already approached a thousand.



One of the first hotels being built on Vulcano in 1960s.

The first guide to the Stromboli craters, Salvatore Di Losa.

In the same period the market for "second homes" also began. In addition to those built during the period of ruthless speculation – again, especially on Lipari and Vulcano – the archipelago offers a large supply of real estate: on some islands, in fact, three out of every four houses are abandoned.

In the early 1970s, the expansion of seasonal residences – both through the construction of new buildings and the rehabilitation of existing ones – is what most characterizes the tourist development of the archipelago, while more the 50 hotels offer nearly 1,500 beds; in 1970 there were 164,400 visitors distributed between hotel and non-hotel facilities. Few minutes of navigation on Internet are enough to understand what happened in the following decades: the accommodation offer grew exponentially, mainly thanks to large funding (such as the Territorial Pact) obtained by local entrepreneurs in the late 1990s; the "official" annual presences – which some sources, however, consider largely underestimated – are around half a million.

In the span of just half a century, tourism has become the archipelago's main economic resource. Since the same time, debates continue at the local level about which model can best respond to the islands' characteristics as tourist destinations.

Indeed, the greatest occurrence of visitors is recorded in summer, because the widespread perception of the Aeolian Islands is that of a seaside resort. In recent years, however, there has been a steady increase in attendance during the spring and autumn, mainly attracted by the islands' environment and landscape.
There are, of course, critical aspects as well: first, the massive number of daily visitors from Sicily and Calabria (exceeding 5,000 units/day), which has a strong impact on carrying capacity of the islands, especially on the smaller ones, while producing very modest benefits to the local economy. Mass tourism also caused a significant increase in the costs related to the management of the services on the islands. For example, according to 2012 data, the annual waste production in the Aeolian Islands is around 700-800 kg per inhabitant (with peaks of 1,262 and 1,223 kg in Panarea and Stromboli, respectively); as a comparison, the regional average is only 550 kg/inhabitant. Such values are even more impressive if we consider their seasonal fluctuation: at Stromboli, for example, the monthly production of waste in July and August is are 8-9 times higher than during winter (up to 186 vs. 20-30 tons). The yearly cost of waste management (collection, storage and transfer to Sicily through special ships) for the archipelago exceeds 5,000,000 euros.

Daily visitors in the harbour of Stromboli.

Urban sprawl

Urbanization deserves a separate mention. Although it has generally affected only limited extents of the islands, in some cases it reached worrying levels, especially on Lipari and Vulcano.
Between the 1960s and the first half of the 1970s, like in the rest of Italy, the municipality of Lipari has issued an exorbitant number of building permits, applying generous indexes even in coastal areas of public property or in volcanic hazard zones. As a direct consequence, hundreds of thousands of cubic meters were built on both islands, consisting mainly of residential houses for touristic purposes. Such initiatives have generated a temporary economic welfare, linked to the building industry.
This strong urbanization was due to the enduring absence of urban planning instruments, which has dragged on until recent times. Indeed, a first attempt should be recalled – as early as 1958 – to endow the municipality of Lipari with a Master Plan. The plan submitted by the project group that won the tender – evocatively titled "The Last Paradise" – prefigured the defence of environmental and cultural assets through farsighted measures, such as the recovery of agriculture and the harmonization between landscape and settlements. This vision, however, conflicted with local expectations, which called for more urbanization as a (questionable) prerequisite for tourism and economic development. Of course, the plan was rejected. Further initiatives – such as the "remarkable public interest" established as a limitation by a 1966 regional law – also proved ineffective.
In 1973, the seminar "Strumenti per la tutela delle Isole Eolie" (Tools for the Protection of the Aeolian Islands) was organized by the environmental association "Italia Nostra".

Unfortunately, the debate turned quickly into a heated clash between supporters of a policy of environmental conservation and advocates of "freedom of action" in the name of supposed social and economic development. It should be noted that the same contrast – currently shifted to the issue of protected areas – is still fully relevant in local debates half century later.
In 1975 the Lipari municipality adopted a transitional urban plan ("Programma di Fabbricazione") whose only merit was to limit the building of new settlements, but certainly not the expansion of the already existing ones.
For a change of course it was necessary to wait another two decades, when the Territorial Landscape Plan drafted by Vincenzo Cabianca was approved by Regional Decree No. 5180/2001. Thanks to the protection measures offered by the TLP, in 2000 the volcanic landscapes of the Aeolian Islands were finally inscribed to the UNESCO World Heritage List.

From left: Ray Bondin, Larry Hamilton, Franco Tassi, Pietro Lo Cascio and Salvatore Pasta during the IUCN-ICOMOS Mission for the inscription of the Aeolian Islands to the WHL UNESCO, February 1999.

Protected areas and conservation: a controversial matter

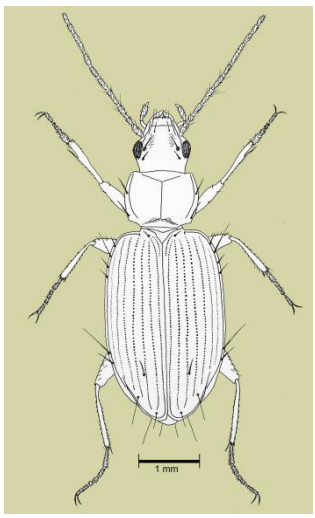
Despite their young geological age, the islands are home to a remarkable number of exclusive endemics. Some of them have small, often narrowly localized populations: for example, *Cytisus aeolicus*, *Silene hicesiae*, *Ephedra strongylensis* and especially *Anthemis aeolica*, are considered "critically endangered" according to IUCN criteria due to the risk of their imminent extinction. Among Vertebrates, the Aeolian lizard *Podarcis raffonei* currently occurs on less than 1% of the total area of the archipelago. An endemic subspecies of the garden dormouse *Eliomys quercinus* has not been observed since 1990s and is probably extinct. Apparently, the situation of endemic invertebrates is less of a concern, but even among them, however, there are cases of extreme rarity: for instance, the ground beetle *Ocys beatricis* has never been found since it was described in 1999.
The annexes of the European Directives 92/43 and 09/147, which protect habitats, flora and fauna, include several priority species occurring in the Aeolian Islands. Apart from the above mentioned *Cytisus aeolicus* and *Silene hicesiae*, the former also includes the rare *Eokochia saxicola*, endemic of few localities of southern Italy and of the islet of Strombolicchio. The latter includes mainly migratory birds, but also some other resident or breeding in the archipelago, such as the Eleonora's Falcon *Falco eleonorae*, the Peregrine Falcon *Falco peregrinus*, the Dartford Warbler *Sylvia undata*, the Cory's Shearwater *Calonectris diomedea*, and the Mediterranean Storm Petrel *Hydrobates pelagicus.*

Furthermore, the islands represent an important stepping stone for more than 200 bird species that cross the Tyrrhenian Sea during the spring and autumn migration: this fact has motivated their inclusion among the European IBAs (Important Bird Areas) and, subsequently, among the SPAs (Special Protection Areas) of the Natura 2000 Network. In addition, there are also 9 SACs (Special Areas of Conservation), which in some cases cover the whole surface of the islands.

In 2000, the Aeolian Islands were inscribed by UNESCO to the World Heritage List (WHC-2000/CONF.204.21) for the importance of their active and extinct volcanoes; until then, the Italian World Heritage Sites included only places of cultural and/or monumental importance.

In the "Mission Report" WHC-07/31.COM presented in 2007 at the 31st session of the World Heritage Committee in Christchurch (New Zealand), Lawrence Hamilton and collaborators proposed to extend the inscription criteria to the terrestrial and marine biodiversity as well. However, this proposal did not receive the needed attention from national and regional institutions, and was even met with mistrust by local institutions, which in those years showed a negative attitude toward UNESCO, especially after the closure of the pumice quarries on the island of Lipari.

To be fair, since 2000 UNESCO put as a condition for the archipelago's inclusion in the WHL that the mining activity – responsible for the dismantlement of the old volcano of Monte Pilato – should cease, and in the meantime called for a sustainable conversion of the quarries. Instead, quarrying continued in an abusive form until the intervention of the judiciary, which permanently closed the pumice quarries in 2007.



The Aeolian lizard *Podarcis raffonei* and the carabid beetle *Ocys beatricis*.

Despite the significant value of the environmental heritage and biodiversity of the Aeolian Islands, the issue of conservation is therefore a rather hot topic.

In 2009, when for the first time the proposed designation of the island as National Park became concrete, according to the Law No. 222 of 12/24/2007, in a few weeks a local "spontaneous committee" collected thousands of signatures against the initiative, leveraging an atavistic distrust that has deep anthropological roots: in fact, islanders tend to frown upon any limitation on their decision-making autonomy, especially if it comes from outside. On the islands, unfortunately, most people think that development comes from the maximum possible exploitation of resources, regardless of its sustainability. On the other hand, it must be admitted that the protected areas so far established for the Aeolian Islands by the regional government, namely the nature reserves ("Riserve Naturali Orientate") of Alicudi, Filicudi, Panarea, Salina and Stromboli, have never yielded results that seem adequate for the protection and enhancement that the islands require.

Four of these are entrusted to a regional department that has neither dedicated staff nor local offices on the islands; moreover, decision-making processes suffer from excessive bureaucratization and, not least, from a conception of the role of protected areas that is often anachronistic, and which essentially results from a lack of knowledge of the environmental and ecological context of the islands.
The National Park – whose creation seems unfortunately unlikely – could finally introduce a homogeneous management suited to an archipelago that constitutes a geographic *unicum*. For example, launching conservation programs for threatened species and habitats, restoring terraced landscapes prone to constant erosion, or containing alien species with greater invasive potential, would require massive interventions, certainly beyond the planning and financial capacities of the managing institutions of the existing protected areas.

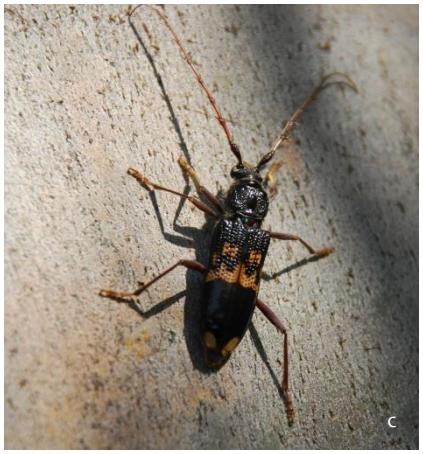
Two alien plants now relatively widespread in the archipelago: *Paraserianthes lophanta* (left) and *Oxalis pes-caprae* (right).

During the last years have been increasing the sightings of *Danaus chrysippus*, an African butterfly that covers long migrations (left); the Eurasian collared dove *Streptopelia decaocto* has colonized the Aeolian Islands since late 1990s (right).

Biological invasions

Biological invasions are not yet perceived as a serious threat to local biodiversity; yet, more than 18% of the current vascular flora of the Aeolian Islands consists of alien species, and year after year new entries are constantly registered. To understand the extent of the phenomenon, it is enough to observe the current spread of the tree of heaven (*Ailanthus altissima*) in the deepest and shadiest valleys of the archipelago, or of those species introduced to create windbreak barriers around the crops and subsequently became weeds, such as the Egyptian cane (*Saccharum biflorum*) at Stromboli or the prickly pear (*Opuntia ficus-indica*) on the southern slopes of almost all the islands. Today it is impossible to imagine an Aeolian winter landscape without the meadows of yellow sorrel (*Oxalis pes-caprae*), native to South Africa and arrived in the archipelago only at the beginning of the nineteenth century. While in the places of origin the species reproduces by seed, the populations introduced in the Mediterranean rarely fructify, as they descend from individuals with short-styled flowers (which hinders pollination) and spread instead through the small bulbs. Agricultural practices have favoured its dispersion, which occurred with an impressive rapidity, particularly in the islands where individuals tend to produce a greater quantity of bulbs and to colonize a wider range of environments than in continental areas.

Recent studies have also shown a rapid expansion for many alien invertebrate species, especially among xylophagous insects belonging to the order Coleoptera.



a) during the last decades *Xanthium orientale* has expanded around the coastal lagoon of the Isthm of Vulcano, b) nowadays *Saccharum biflorum* extensively covers the northern slope of Stromboli, including the small early 20th century cemetery, c) the Australian longhorn beetle *Phoracanta semipunctata* has recently colonized the *Eucalyptus* reforestations on Salina and Vulcano.

Plant life on the Aeolian Islands

The Aeolian archipelago currently hosts nearly 930 vascular plants. In other words, approximately 25% of the whole Sicilian flora occurs in a fragmented territory whose extension is only 0.5% of the regional surface. On the one hand, this data clearly points out the outstanding inherent value of local botanical heritage. On the other hand, the exceptionally high rate of alien plants (c. 18.3%), nearly doubling that recorded for the whole Sicilian territory (c. 10%), confirms the vulnerability of Mediterranean small volcanic islands to alien plant invasion and underlines the urgent need of adopting appropriate measures to avoid future irreversible environmental disruption and prevent the risk that local endemic may be outcompeted and go extinct because of alien plant invasion.

Nowadays the seven main islands of the Aeolian archipelago host a complex patchwork of old fields, or, where successional processes have been able to erase most signs of human activity, by annual swards, perennial xerophytic grasslands, garrigues and dense thickets. Few and small spots of evergreen forest occur in the less disturbed areas of Salina, Lipari and Filicudi. These species-poor communities are dominated by strawberry trees (*Arbutus unedo*), tree heathers (*Erica arborea*) and holm oaks (*Quercus ilex*). The presence of some isolated huge holm oaks (Vulcano and Alicudi), as well as the sporadic presence of downy oaks (*Quercus pubescens*) and old chestnut trees (*Castanea sativa*) on almost all islands confirms the good potential of the Aeolian Islands for both evergreen and deciduous forests. The past presence of native Aleppo pine forests (*Pinus halepensis*) needs to be confirmed. Today only Panarea and Stromboli are totally devoid of wood cover, probably because large portions of their surface were transformed in extensive olive groves and vineyards, respectively. During the second half of the 20th century, some areas of Salina and Vulcano have been planted with allochthonous trees (mainly *Pinus* spp. and *Eucalyptus* spp., respectively).

a) Maquis with *Erica arborea* and *Arbutus unedo* at Lipari, b) old *Castanea sativa* grove on Monte Fossa delle Felci, Salina, c) *Quercus pubescens*, Alicudi, d) pine reforestation on Capo Grillo, Vulcano.

Despite the disruption and degradation of many semi-natural habitats occurred during last 60-80 years, the Aeolian archipelago is still home to a remarkable environmental heterogeneity, hosting as many as 25 different terrestrial habitats of community interest according to the 92/43 "Habitats" Directive. Among the most noteworthy and fragile sites, a particular mention should be given to the small coastal lagoons of Lingua (Salina) and Pantano (Vulcano), the sandy beaches of Stromboli, Vulcano and Panarea, the rocky cliffs of Alicudi and Panarea, and some stacks like Strombolicchio (Stromboli), la Canna (Filicudi) and Scoglio Faraglione (Salina). During the last decades, the steep demographic increase of feral herbivores on many islands represents an overlooked, yet increasingly worrying threat to local biota.

a) the coastal lagoon of Isthm on Vulcano, b) dune vegetation on the sandy beach of Sabbie Nere, Vulcano, c) rocky cliffs of the western slope of Alicudi, d) *Seseli bocconei* on the rocky cliffs of Panarea.

Biological similarity and distinctness: just a question of volcanic unsteadiness and random colonization?

Many plant species that are common throughout the Italian and Sicilian territory are present and widespread in the main islands of the Aeolian archipelago; however, several of them are unexpectedly missing on one single island. The "primacy" of exclusive absences is disputed by the islands floristically poorer and subject to the most intense volcanic activity over the last centuries (Stromboli 25, Vulcano 16). Such pattern probably depends on the higher frequency and intensity of various forms of natural disturbance (e.g., emission of toxic gases, rock collapses, bomb ejections, pyroclastic surges, fires, sudden deposition of hot and thick tephra and sand layers) linked with the recent volcanic activity that occurs on the two islands. Such hypothesis seems to be confirmed by the fact that several other species are missing only in both Stromboli and Vulcano (for instance most of the woodland species occurring on the other Aeolian islands). The second factor seems to be the peripheral position due to the distance from Sicily and/or the other islands of the archipelago. In fact, Alicudi, located at the westernmost edge of the archipelago, counts 13 exclusive absences, followed by Panarea (7) and Filicudi (3), while Lipari and Salina, the largest and aligned to form almost the "spine" of the Aeolian Islands, count respectively only 2 and none of the "exclusive lacking" species. The important role played by distance seems to be confirmed by the fact that many other plants are missing only in both Alicudi and Filicudi or only in both Panarea and Stromboli, forming the westernmost and easternmost portion of the archipelago, respectively.

a) small and scattered therophytes represent the only plant life on the slag and debris soil of the upper part of Gran Cratere, Vulcano, b) *Genista tyrrhena* formations on the sandy slopes of the Gran Cratere , c) wild *Ficus carica* individuals form «islands» of vegetation (functionally identical to the north-African «nebkas») where few other species can grow on the sandy slopes of Stromboli.

An equally marked result comes out from the analysis focused on the number of native taxa present on a single island, which are as many as 127 (c. 17% of the entire native flora!). Lipari, the largest island of the archipelago, alone hosts 56 exclusive species, followed by the westernmost, Alicudi (25), Surface and landscape heterogeneity alone seem insufficient to justify the large number of species exclusive to Lipari, while the relatively high number of Alicudi could once again depend on its peripheral position. Relatively lower is the number of species exclusive to Filicudi (14), Salina and Panarea (12). Once again, the floristically poorest islands, whose natural habitats have probably suffered from repeated partial or total destruction, are also those with the lowest number of exclusive species (Volcano: 7, Stromboli: 1).

The relict, the endemic and the disjunct: the Aeolian flora, an intriguing puzzle for island biogeographers

Only few scientific works tackle the palaeogeographical aspects trying to interpret the floristic patterns of the Aeolian Islands in the historical biogeographical perspective, that is, going beyond considerations based on the simple count of endemic and exclusive taxa and on floristic similarity. The enormous improvements in our understanding about the volcanic history of the Aeolian Islands highlights the glaring and inexplicable contradiction between the distribution of the narrow endemic, disjunct and relict species living there, and the extremely young age of the archipelago. For sure, the so-called Messinian salinity crisis, occurred between 5.9 and 5.3 million years ago and used in the past decades to explain the disjunct distribution of some plants also occurring on the Aeolian islands, can no longer be invoked, since the archipelago emerged much later. Moreover, the continuous upheavals of the Aeolian biota make doubt that the Aeolian Islands may have played a role as climate refuge during the Quaternary glaciations.

Iberis semperflorens on the rocky cliffs of Panarea.

As a matter of fact, the Aeolian Islands host several ancestral and narrow-ranged plants with an extremely fragmentary distribution pattern across the Tyrrhenian Sea, like *Glandora rosmarinifolia*, *Iberis semperflorens* and *Eokochia saxicola*. Many other local endemics, like *Dianthus rupicola* subsp. *aeolicus*, *Genista tyrrhena*, *Helichrysum litoreum*, *Centaurea aeolica*, belong to the Tyrrhenian element, too. The closest relatives of another outstanding Aeolian endemic, *Silene hicesiae*, grow in the western Mediterranean, home of other disjunct plants occurring on the Aeolian archipelago, like *Hyoseris taurina* and *Succowia balearica*.

Paleogeography may help explaining the complex and still poorly understood interplay of source and target areas of plant dispersal trajectories. With the exception of *Limonium minutiflorum*, which grows also on the "fossil" island of the Milazzo Peninsula just 20 km south of Vulcano, the closest populations of the Sicilian endemics growing on the Aeolian archipelago, such as *Ranunculus rupestris* and *Seseli bocconei* subsp. *bocconei*, are instead located on the calcareous massifs of NW-Sicily.

The available floristic data point to the complex role played by Aeolian islands as stepping-stones in the plant dispersal of central- and western-Mediterranean plants and confirm the extreme randomness of the processes of colonization, success, and survival of plants on the most distant and/or thalassogenic islands.

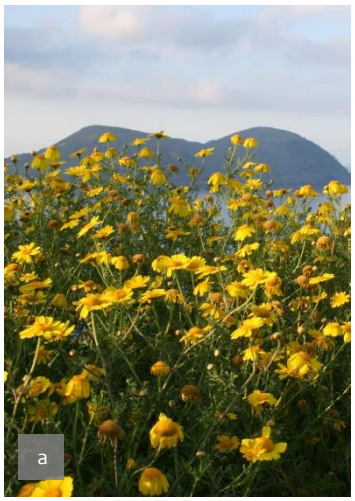
Future research should be addressed at clarifying the patterns of similarity and distinctness of islands' biota, targeting different groups of organisms, namely the less mobile (and more informative) ones.

Moreover, population genetic analyses may help solving at least some of the enigmas posed by the current distribution of the endemic, narrow-ranged and disjunct species, and to better interpret the local history of plant colonization and evolution.

a) *Ranunculus rupestris*, Alicudi, b) *Helichrysum litoreum* on the rocky shores of Vulcanello, Vulcano, c) *Eokochia saxicola*, Strombolicchio Islet, d) *Hyoseris taurina*, same islet.

Land use change, fading habitats, extinctions and species turnover

The Aeolian landscape has deeply changed since the first floristic inventories, carried out already at the beginning of the 19th century. At that time the daily life of most of the islanders was devoted to traditional agro-pastoral activities, so that only the most sterile, remote, and inaccessible areas were left uncultivated, and only few trees were spared to provide fruit or shade during the hot summer afternoons. On the other hand, herbarium specimens confirm the past occurrence of habitats which have been destroyed during last century, like temporary ponds and some coastal plant communities.
The number of extinct plant species is extremely high, especially on larger islands. The ecology of extinct species allows us to interpret this process in the light of the important changes that have involved local traditional activities. In fact, local people have moved from a rural economy essentially based on agriculture to one aimed at exploiting seasonal tourism. On the one hand, this triggered the strong degradation and fragmentation of coastal ecosystems due to urbanization, and on the other hand, it has caused the gradual abandonment of higher and inland areas. As in many other places in the Mediterranean, significant changes in land use have resulted in the gradual disappearance of local traditional activities and landscapes, also leading to the rarefaction and disappearance of entire plant communities particularly rich in ruderal annual species. Recent floristic investigations pointed out that approximately 70 species have disappeared from the whole archipelago, and that many of them were archaeophytes (= plants whose distribution is tightly connected since millennia with extensive agriculture practices). In the meantime, the coastal urbanised areas of the Aeolian islands are home to an ever-growing number of alien plants, that were purposedly introduced as ornamental or reached the archipelago by chance.



a) *Glebionis coronaria* is widespread in recently abandoned fields, b) olive groves in the terraces of Filicudi, c) traditional vineyards in Quattropani, Lipari, d) perennial xerophytic grassland at Palmeto, Lipari.

Plant succession on abandoned terraces: give pace a chance…

Over the past centuries the Aeolian Islands have been the scene of massive transformations, with the setup of dry-stone wall terraces for agricultural purposes, a rather common practice in the coastal and island areas throughout the Mediterranean. Some of these manufacts present an absolute historical and cultural interest, considering their extension (e.g., Alicudi, Filicudi, Salina), the size of the stones used (e.g., Filicudi) and the almost inaccessible contexts (e.g., Alicudi) in which these terraces were made to obtain cultivable surfaces. The extent of many of these terraces may seem negligible to us, but we must look at these works with the eyes and hunger of the farmers of the past. Studies conducted in very similar environments on another circum-Sicilian Island, Pantelleria, located between SW-Sicily and Tunisia, have shown that in the absence of disturbance and where the terraces were close to uncultivated areas with pre-forest vegetation nuclei, the woody species were able to colonize the abandoned terraces and to form mature, dense and species-rich maquis over 30-40 years. In the case of the Aeolian archipelago, this process is often hampered, slowed down, or even interrupted by disturbance (e.g., overgrazing, trampling and dry-stone wall collapse caused by domestic and feral herbivores, wildfires).

a) *Onopordon horridum* extensively covering areas where overgrazing occurs on Piano, Vulcano, b) low maquis with *Euphorbia dendroides*, *Pistacia lentiscus* and *Artemisia arborescens* on Salina, c) *Cistus* spp. grow on abandoned terraces on Panarea.

"Brand new" endemics: recent differentiation, recent description and ongoing interpretation

Some species described two centuries ago and considered for a long time as endemic exclusive to the Aeolian Islands have not withstood the progress of plant systematics. This is the case of the leafy wild carrot, *Daucus foliosus*. Described by Gussone in 1832, it was very soon placed in synonymy with *D. nitidus*, described by the same author in 1855 for the island of Ischia, and is featured as a mere synonym of *D. gingidium* subsp. *fontanesii* in the most recent monographs on wild carrots. On the other hand, over the last decades other local endemics have instead been re-evaluated after a century of oblivion. A special case is provided by *Anthemis aeolica*, a very localized and threatened small island specialist, whose last population currently grows on Lisca Bianca, a tiny islet off Panarea. As for the other three Aeolian narrow endemic plants discovered over the last twenty years, i.e., *Bituminaria basaltica* (Filicudi), *Erysimum brulloi* (Alicudi) and *Ephedra strongylensis* (Stromboli and Strombolicchio), their description is based on morpho-anatomical and ecological criteria and to date there are no studies available that allow to fully evaluate neither their affinity nor the possible timing of their differentiation with respect to the most closely related species.

Alicudi's wallflower *Erysimum brulloi* Ferro (fam. Brassicaceae)

Erysimum L. is one of the largest genera of the family Brassicaceae, including more than 220 species, recently framed into the unigeneric tribe Erysimeae. The evolutionary history of this genus is complex: due to recurrent events of inter-specific hybridization and polyploidization, *Erysimum* is characterized by multiple base chromosome numbers, and reticulate evolution has probably triggered the enormous rise of cryptic species number.
Erysimum brulloi is endemic to the island of Alicudi, where it grows between 300 and 650 m a.s.l. on volcanic lithosoils, mostly occurring in abandoned fields (*Echio-Galactition tomentose*) and garrigues (*Cisto-Ericion*). *E. brulloi* is a subshrub, whose erect stem bears several densely leafy prostrate-ascending lateral branches. Leaves are evergreen, linear to linear-oblanceolate, 3-10(12) cm long, 2-5(9) mm wide. The flower-rich racemes are paniculate. This plant provides a good example of the gradual and sometimes slow and "twisted" progress of plant taxonomy. In fact, it was described as a narrow endemic species new to science nearly two centuries after being discovered by G. Gussone in 1828. Out of curiosity, 150 years later, during his stay at the Aeolian islands (late 1970s), one of the most renowned European specialists of genus *Erysimum*, the Austrian botanist Hans Metlesics, missed to visit Alicudi. The species was then searched, found (and overlooked) by S. Pasta in the 1990s, then collected by Gioachino Ferro's collaborators at the beginning of the 2000s.

Aeolian sea-cliff chamomille *Anthemis aeolica* Lojac. (fam. Asteraceae)

The genus *Anthemis* counts about one hundred species mainly distributed in the Mediterranean area and in western Asia up to Iran and Iraq. Many annual species are adapted to colonize coastal environments and some of them, such as *A. scopulorum* Rech. f. and *A. glaberrima* (Rech. f.) Greuter, led to the coining of the term "Small Island Specialist" and stimulated the inventory of narrow-ranged plants preferring – or only occurring on – islets.

Other *Anthemis*, instead, have managed to colonize mountain massifs, sometimes becoming woody species, like *A. punctata* Vahl, growing on the Algerian and Tunisian Atlas, or *A. cupaniana* Tod. ex Nyman, common on the hilltops of central-western Sicily.

During the last 20-30 years enormous progress has been made in the field of systematic and evolutionary interpretation of the entire tribe Anthemideae on a Mediterranean scale.

Such advances have served to clarify the taxonomic significance and the possible origin of many wild chamomilles described for Sicily and its satellite islands not only in past centuries, but still over the last ten years, such as *A. pignattiorum* Guarino, Raimondo & Domina and *A. todaroana* Raimondo, Bajona, Spadaro & Di Grist.

A. aeolica had been described as a variety of *A. maritima* L. by Gussone, the first botanist who had observed it growing on several stacks off Panarea in the early 18th century. Fifty years later, Lojacono-Pojero had described it as an autonomous species and had reported its presence also for the island of Stromboli.

A century later, accurate prospecting has made it possible to ascertain the presence of a single population of this species, located on the islet Lisca Bianca. This population is currently threatened by the competition of the invasive alien *Carpobrotus edulis* (L.) N.E. Br.

Basalt-loving pitch trefoil *Bituminaria basaltica* Minissale et al. (fam. Fabaceae)

The small genus *Bituminaria* has a Mediterranean centre of gravity with one species also present in the Canary Islands and another also growing in the Iranian-Turanian area. Until ten years ago, it counted only four species, namely *Bituminaria acaulis* (Turkey, Georgia and southern Russia). *B. morisiana* (Sardinia), *B. flaccida* (Egypt, Israel, Jordan) and *B. bituminosa*, in whose variability were included all the populations of the central-western Mediterranean of pitch trefoil.
However, the intense collection campaign promoted over the last decades in several Mediterranean countries by prof. S. Brullo and his collaborators of the University of Catania has allowed the observation of live plants in cultivation, allowing to better grasp the phenological and morpho-anatomical differences, sometimes clear from the early stages of germination and development, between different taxa.
Over the last ten years, these observations have suggested to frame *B. acaulis* into the distinct monotypic genus *Kartalinia*, to revive *B. palaestina* (Palestine) and supported the description of six species new to science, namely *B. basaltica*, endemic to Filicudi Island, *B. kyreniae* (Northern Cyprus), *B. plumosa* (northern Croatia), *B. tunetata* (Tunisia), *B. antiatlantica* and *B. atropurpurea* (Morocco).
B. basaltica shows a similar general habit and shares the same ecological requirements of *B. bituminosa*; yet, unlike its close relative, it does not give off the typical unpleasant smell of tar, and appears well differentiated for many morphological traits, like the size and shape of leaves, inflorescences, flowers, pods, seeds, which are generally smaller, and the colour of the corolla, which is always white, and not blue-violet like in *B. bituminosa*. It grows between 20 and 100 m a.s.l., taking part to dry grasslands dominated by *Hyparrhenia hirta* (L.) Stapf in the abandoned fields and roadsides of the southeastern sector of Filicudi. It flowers between April and early June while fruiting occurs between June and August.

Giant Aeolian broom *Cytisus aeolicus* Guss. (fam. Fabaceae)

In his "History of Plants" (3rd century BCE), Theophrastus mentioned the *koloitía perí Lipáran*, a tree-like broom, clearly referring to a woody plant which still grows only in this archipelago, *Cytisus aeolicus*. This early mention of an Aeolian plant is a paradigmatic example of the unended appeal of local vascular flora over life scientists.

Indeed, the occurrence of this very odd (and evolutionarily old) plant on a very young archipelago represents an enigma that generations of island biologists have not yet been able to fully solve.

This plant exists in the Aeolian Islands at least since early Pleistocene, as evidenced by the discovery of perfectly preserved leaf footprints in volcanic ashes of Lipari dating back to 100,000 years ago.

It is a pioneer evergreen tree of small size with a very early flowering season (late February-mid-April). Characterized by a rather rapid growth and a short life cycle, in natural conditions *C. aeolicus* rarely exceeds the 5 m of height and has a characteristic globular habit; however, on deeper and richer soils it can reach 8 m in height but is subject to sudden die-offs. Like the other most remarkable "living fossils" and climatic relicts of the Sicilian vascular flora, it appears completely detached from the vegetation in which it lives.

Its current distribution seems to mirror that of the islands affected by more recent volcanism. The populations of Vulcano and Alicudi, discovered less than 30 years ago, are very small and in regression, while that of Stromboli, after a phase of strong contraction, during the last 25 years experienced an unexpected demographic explosion, perhaps favoured by the increased intake of H_2O and CO_2 provided by local volcano.

Cytisus aeolicus at Stromboli, 500 m a.s.l.

A large number of morphological traits have led specialists to place *C. aeolicus* in a distinct subgenus within the genus *Cytisus*. New investigations with modern approaches could clarify its degree of kinship with other genera of the tribe Genisteae and shed light on the possible origin of a plant whose differentiation appears older than the islands on which it grows.
Apparently unharmed by herbivores, as it is despised by feral goats, *C. aeolicus* appears, however, strongly vulnerable to fire and cutting, showing very little or no vegetative response capacity.
Its wood was used to make poles to sustain the vineyards and for the construction of sledges for the transport of the twigs. To confirm its historical importance in the local landscape, this plant has an exclusive dialectal name, "sgurbiu", probably the result of the distortion of the Greek "skorpios", which in turn refers to its slightly arcuate pods, vaguely recalling the skorpion's tail.

Aeolian Smooth catchfly *Silene hicesiae* Brullo & Signorello (fam. Caryophyllaceae)

Silene hicesiae is a 30-50 cm tall subshrub bearing both sterile and fertile rosettes with densely hairy, elliptical leaves, 1-2 cm broad, 3-10 cm long. The fertile rosettes produce an usually non-branched flowering shoot with a 30 to 70 cm long stem with bunches bearing pink to pale pink 5-petal flowers which open in May. The fruits ripen between July and August, when they release their seeds and let them fall down to the ground.

S. hicesiae belongs to the "*Silene mollissima* group", which includes at least seven species endemic to the coastal cliffs of the western Mediterranean basin. For several decades this species complex has been cited as a remarkable example of how geographic isolation may trigger the evolution of new species through genetic divergence mechanisms. However, new research suggests a far more recent differentiation of this species group.

The population of *S. hicesiae* is severely fragmented. In fact, the two known subpopulations are situated ca. 60 km apart, with probably more than 80% of individuals concentrated at Panarea, where approx. 1500-2500 individuals grow within a grassland community dominated by *Brachypodium retusum* on the steep and stony slopes of Punta del Corvo. The current size of the second subpopulation, located at Alicudi, is probably underestimated due to incomplete field surveys. Imagery obtained on purpose by means of drone flights carried out in the framework of a Life Project "SeedForce", aiming at improving the conservation status of around 30 Italian plant taxa included in the Annex II of the EC 'Habitats' Directive, reveals that dozens of very scattered individuals of *S. hicesiae* grow on the volcanic cliffs and the mobile ash debris of this hardly accessible sector of the island (A. Cristaudo, *pers. comm.*; https://lifeseedforce.eu/en/unict-monitoring-with-drone/)

Featured among the priority species in Annexes II and IV of the EC 'Habitats' Directive, *S. hicesiae* is mainly threatened by wildfires and browsing by feral herbivores at Alicudi, while the subpopulation of Panarea risks to be outcompeted by *Agrostis castellana* and *Ailanthus altissima*.

S. hicesiae deserves regular monitoring and further field investigations to improve available knowledge on its ecology and distribution and on the demographic trend of both subpopulations.

Silene hicesiae at Panarea, 400 m a.s.l.

a, f) *Genista tyrrhena*, b, e) *Dianthus rupicola* subsp. *aeolicus*, c) *Limonium minutiflorum*, d) *Centaurea aeolica* subsp. *aeolica*.

Faunal assemblages and diversity

The faunal assemblages of the Aeolian Islands reflect the main geographical features of the archipelago: volcanoes that emerged in recent times, without rivers or lakes except for two small coastal lagoons, the islands host only a low number of species of terrestrial Vertebrates (6 Reptiles, 7 Mammals excluding Chiroptera), and Amphibians are lacking, although the presence of the green toad and perhaps even frogs (certainly introduced) has been reported in the past. However, two endemics occur, one of which in particular – the Aeolian lizard – has great conservation importance. Birds are the largest group, with more than 50 resident or breeding species. Moreover, the islands lie along the migratory routes across the Tyrrhenian Sea.
Invertebrates also include several species of biogeographical interest, but it should be noted that some groups have not yet been adequately studied.

Checklist of endemic terrestrial fauna of the Aeolian Islands

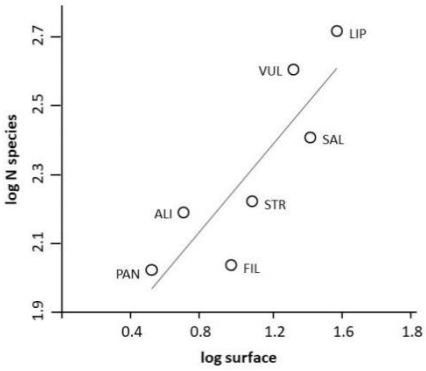
MOLLUSCA GASTROPODA
Helicotricha carusoi Giusti, Manganelli & Crisci
Hypnophila incerta (Bourguignat)
Limax aeolianus Giusti
Oxychilus alicurensis (Benoit)
Oxychilus lagrecai Giusti
ARACHNIDA ARANEAE
Dysdera flagellifera ssp. *aeoliensis* Alicata
Harpactea aeoliensis Alicata
ORIBATIDA
Passalozetes paucesculptus Bernini
HEXAPODA COLLEMBOLA
Friesea lagrecai Dallai
Pseudosinella aeolica Dallai
Seira dagmae Dallai
BLATTARIA
Ectobius aeoliensis Failla & Messina
Ectobius filicensis Failla & Messina
HOMOPTERA
Adarrus aeolianus D'Urso
COLEOPTERA
Anoxia moltonii Sabatinelli
Anthaxia flaviae Sparacio & Lo Cascio
Bruchidius salinaensis Zampetti & Toma
Catomus aeolicus Ponel, Lo Cascio & Soldati
Firminus massai Arnone, Lo Cascio & Grita
Leptoderis zelmerloewae Ferrer
Nalassus pastai Aliquò, Leo & Lo Cascio
Ocys beatricis Magrini, Cecchi & Lo Cascio
Otiorhynchus meligunensis Magnano
Pseudomeira aeolica Bellò, Pesarini & Pierotti
LEPIDOPTERA
Hipparchia leighebi Kudrna
DIPTERA
Allotrichoma pseudolaterale Raffone
VERTEBRATA SQUAMATA
Podarcis raffonei ssp. *alvearioi* (Mertens)
Podarcis raffonei ssp. *raffonei* (Mertens)
MAMMALIA
Eliomys quercinus ssp. *liparensis* Kahmann

Above, *Hipparchia leighebi*; below, *Oxychilus* sp.

"An inordinate fondness for beetles"

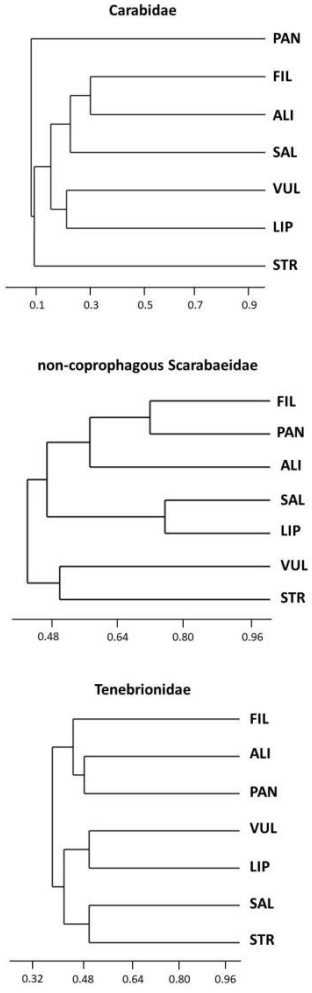
The beetle fauna of the archipelago includes on the whole 861 species, the largest number so far known for the circum-Sicilian island groups. Within the main islands, it ranges from 547 (Lipari) to 116 species (Panarea), and species richness is significantly correlated to the island area (log N species-log surface: $r^2 = 0.734$, $P = 0.01$), while less or not significant correlations occur considering their isolation ($r^2 = 0.582$, $P = 0.04$) or elevation ($r^2 = 0.003$, $P = 0.8$).

About 50% of the species recorded for the archipelago is known only for a single island. The percentages differ however between families and/or groups, with highest values resulting for those that include a large number of predators (e.g. Carabidae: 62%), or constrained by a narrow ecological specialization (e.g. coprophagous Scarabaeidae: 69%), and the lowest for non-coprophagous Scarabaeidae (23%) or Tenebrionidae (27%). It should be noted that ground beetles are extremely sensitive to habitat alteration, hence their selective distribution might be influenced by land use changes that occurred in the recent time. A different matter concerns the dung beetles, whose occurrence is strongly linked to pabulum availability: some old records for islands where cattle breeding is currently ceased (such as Lipari, Salina and Stromboli) have not been recently confirmed, while on Vulcano (where livestock is still occurring) dung beetle communities seem to be stable through time.



Left: the dung beetle *Scarabaeus sacer* is rare at regional scale but still common on Vulcano. Right: Species-area plot for the beetle assemblages of the archipelago; islands' abbreviations: ALI) Alicudi, FIL) Filicudi, LIP) Lipari, PAN) Panarea, SAL) Salina, STR) Stromboli, VUL) Vulcano.

Only a small percentage (1.6%) of the species occur instead on all the seven main islands: in most cases are synanthropic or widely distributed species, but this group includes also the Italian endemic *Aplidia hirticollis* (Scarabaeidae), the narrow endemic *Otiorhynchus meligunensis* (Curculionidae), and even *Ozognathus cornutus* (Ptinidae), a north-American death-watch beetle that has only recently colonized the Aeolian Islands. The dynamics of colonization and dispersal of beetles on and/or within the archipelago was the subject of authoritative studies, whose results appear to be sometimes controversial. The origin of this fauna was generally considered recent, and species seem to have established on the islands mainly by stepping stone dispersal or inter-island faunal exchanges, without being influenced by island age. However, in the case of the widespread, apterous darkling-beetle *Pimelia rugulosa*, volcanism could have influenced spatial patterns of genetic variability: the archipelago hosts separate lineages that have independently colonized different islands from the mainland and have differentiated locally forming small haplogroups, whose variability is correlated with island age and in some cases presumably depleted by catastrophic events.



Above: dendrograms obtained by UPGMA clustering of the islands with Jaccard index similarity matrix for some groups. Right: three endemics, a) *Anoxia moltonii* (Scarabaeidae Melolonthinae), b) *Nalassus pastai* and c) *Leptoderis zelmerloewae* (Tenebrionidae).

An average linkage cluster analysis (UPGMA) using Jaccard's coefficient suggests that the distribution of Carabidae within the archipelago is mainly influenced by the geographical proximity, while island size (and presumably environmental heterogeneity) is the main factor determining similarity both for Tenebrionidae and non-coprophagous Scarabaeidae. For this latter group, two islands (Vulcano and Stromboli) are clustered in a rather isolated position, probably due to their distinctive environmental resemblance (large areas occupied by active volcanoes, wide representation of sandy habitats, etc.).

Volcanic activity and stochastic events could have played a role in micro-evolutionary processes for some populations (e.g. through repeated bottle-neck effects), as suggested for instance by the occurrence of the neo-endemic *Anoxia moltonii* on Vulcano, while its closely related *A. matutinalis* is found on Lipari (just 1 km from this island) and Salina. The relatively recent age of the archipelago is expected to be a constrain for speciation processes, and the endemics are in fact only 1.17% of the whole fauna, with 10 species exclusively distributed on one (3) or more islands (7). For some endemics, taxonomic isolation suggests however an ancient origin (e.g. the carabid *Ocys beatricis* or the tenebrionid *Nalassus pastai*), thus their occurrence has been interpreted as relictual.

Despite this low endemism rate, the Aeolian faunas show however a certain distinctiveness: some species are known at regional scale exclusively for the archipelago (*Ophonus rufibarbis*, *Psammodius plicicollis*, *Eucinetus haemorrhoidalis*, *Atomaria turgida*, *Melanophthalma sericea*, *Stenurella nigra*, *Trichoferus spartii* and *Longitarsus candidulus*). Furthermore, the islands host species of biogeographic interest, rare or strictly localized at regional or national scale (*Atholus siculus*, *Heterothops canariensis*, *Rhagonycha lignosa*, *Anthrenus biskrensis*, *Longitarsus australis, L. gracilis*, *Caulostrophus zancleanus*).

Recent records indicated the occurrence of a large number of alien species, such as *Ozognathus cornutus* (Ptinidae), *Colopterus abdominalis*, *Epuraea ocularis, Epuraea luteolus* (Nitidulidae), *Sericoderus brevicornis* (Corylophidae), *Harmonia axyridis* (Coccinellidae), *Phoracantha recurva*, *P. semipunctata*, *Xylotrechus stebbingi* (Cerambycidae), *Aclees taiwanensis*, *Gonipterus* sp. and *Rhynchophorus ferrugineus* (Curculionidae). Especially in the case of the ptinid *O. cornutus*, it is noteworthy as this species was able to spread very quickly, as suggested by its findings on all the main islands just few years after its first record for Sicily. Also the nitidulid *Epuraea luteolus* was collected on the uninhabited islet Strombolicchio in 1999, only one year after its first record for Sicily. The amount of exotic species recently detected suggests an increasing trend and confirms that islands are extremely exposed to biological invasion and colonization from alien beetles, a phenomenon now widely documented both at Mediterranean and at global level. Alien species pose a threat not only to local biodiversity, but also to traditional rural activities – for instance, the potential of damage expected by the fig pest *Aclees taiwanensis* – and therefore require urgent prevention and monitoring measures, which however do not seem easy to implement in the continuing absence of an effective and sustainable management of these islands.


a


b


c

Above, some rare species: a) the Tyrrhenian endemic *Enoplium doderoi* (Cleridae), b) *Anthicus crinitus* (Anthicidae), so far known in Italy only for two localities on Sicily and Aeolian Islands, c) *Hypothenemus leprieuri* (Curculionidae Scolytinae), known in Sicily only for the Aeolian Islands. Below, three narrow endemics: d) *Firminus massai* (Scarabaeidae Melolonthinae), e) *Anthaxia flaviae* (Buprestidae), f) *Catomus aeolicus* (Tenebrionidae). (images not in scale)


d


e


f

Birds, mammals and reptiles

Birds are the largest group among the Vertebrates of the archipelago, with 59 breeding species (including those recorded in the past but not confirmed) and more than 200 recorded as migratory and wintering species. Some of the breeding ones have remarkable conservation importance and are included as priority species in the EU Directive 09/147: the Peregrine falcon *Falco peregrinus*, the Eleonora's falcon *Falco eleonorae*, the Cory's shearwater *Calonectris diomedea*, the Mediterranean Storm petrel *Hydrobates pelagicus* ssp. *melitensis* and the Dartford warbler *Curruca undata*.
The latter occurs with the largest populations (about 60-80 pairs) known at regional scale and is localized in the high shrub formations dominated by *Erica arborea* on the upper part of the islands (from 300-400 m a.s.l., especially on Lipari, Salina and Filicudi). It is not easy to detect this species, which usually lives in dense vegetation, moving to coastal areas during winter, and is characterized by elusive behaviour; moreover, it can be confused with *Curruca cantillans*, which can be distinguished for the less elongated tail and grayer plumage in the upper parts. The diet is essentially insectivorous, but out of the breeding season it also feeds on berries and fruits. Nests are usually built no more than one meter high from the soil. Between March and April, the female lays 3-4 eggs that are incubated for 12-14 days; hatchings leave the nest after a couple of weeks.

Above, the Dartford warbler *Curruca undata*; below, the Cory's shearwater *Calonectris diomedea*.

The Cory's shearwater *Calonectris diomedea* spends most of its life in the pelagic habitat and approaches the coasts exclusively during the reproductive season. Colonies can also be very numerous (more than 100,000 pairs on Zembra Island, Tunisia), but the whole consistence of the Aeolian populations is estimated to be around 100 pairs, mainly localized on the cliffs of the western coasts of Vulcano and Salina and on some islets.
During the nesting activity, adults emit typical vocalizations. Females lay a single egg, incubated by both sexes for about 50 of days. In the last weeks of growth, the hatchlings come to exceed the weight of the adult before they leave the nest.
The diet is based on fish, cephalopods and crustaceans, caught in the open sea. A survey of the movements of some individuals from the Aeolian colonies, carried out through GPS tracks, has shown that they cover up to 225 km for foraging, reaching as far as the central Tyrrhenian Sea.
The species is included in Annex 1 of the EU Birds Directive 09/147. Among several threats – such as the depletion of fishery resources, pollution from heavy metals, anthropization of the coasts, and disturbance or predation by gulls and rats – there is also the collection of eggs and chicks by humans, taken for food; however, such illegal practices – unfortunately still widespread on some Mediterranean islands – do not belong to the Aeolian popular traditions.

The Mediterranean Storm Petrel *Hydrobates pelagicus* is the smallest marine bird of the European fauna, reaching just 15 cm in length. It lives in pelagic habitat for most of the year and approaches the coast only during the reproductive season. In the open sea, it feeds on small crustaceans, molluscs, fish and jellyfish, which it catches at the surface or even few meters under the sea level.
The populations of the Mediterranean belong to the ssp. *melitensis*, while the Atlantic ones are referred to the nominal form.
It nests generally in caves on the rocky coasts, exclusively localized on small islands. Except for few cases, such as Marettimo (Egadi Islands) and Filfla (near Malta), the colonies rarely have more than a hundred pairs.
During the summer months the female lays a single egg, which is hatched for about 40 days; the hatchlings leave the nest after 60-80 days. Adults take turns in parental care, approaching the nest after sunset. During the first weeks they make several sorties per night to feed the chick, while the frequency of foraging decreases when the chick grows.
The species was first found in the Aeolian Islands in late 19th century at Lisca Nera, an islet near Panarea now almost entirely destroyed by marine erosion. Thirty years ago a single nest was found at Filicudi, but not confirmed successively. During the last two decades two new colonies have been found by P. Lo Cascio at Scoglio Faraglione (Pollara Bay, western coast of Salina) and Montenassari (near Filicudi). The whole population of the archipelago (the only occurring in southern Tyrrhenian Sea) is estimated at about 50-60 pairs. Both islets are not inhabited by the black rat, a dangerous predator of chicks and eggs. In spite of this, a high rate of reproductive failure (abandoned eggs and/or dead chicks) has been recorded at Scoglio Faraglione, probably related to gulls' disturbance or other factors not yet clarified.

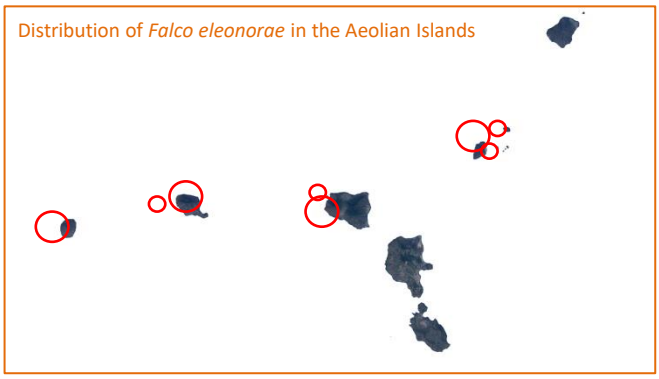
Above, an adult and a chick of the Mediterranean Storm petrel *Hydrobates pelagicus*; right, the islet Montenassari near Filicudi hosts about 80% of the Aeolian population of this species.

The Eleonora's falcon *Falco eleonorae* is an iconic species of the small Mediterranean islands, where it returns each summer for the reproduction after a long trans-Saharan migration. It is characterized by two phenotypic forms: in the "light" form, individuals have uniform brown upper parts and lower parts with dark streaks, while in the "dark" one the plumage is entirely brown. However, the genotypic forms are three (one light homozygous, one dark heterozygous, and one dark homozygous) and their frequency follows Mendelian laws, with the representation of dark phenotype in the 28% of the global population (35% in Alicudi).

The Aeolian colonies are localized on the coastal cliffs exposed to the west or northwest (hence, to the dominant winds) of Alicudi, Filicudi and the nearby La Canna, Salina, Panarea; the species occurred irregularly at Strombolicchio and in recent years has also colonized the islets of Basiluzzo, Spinazzola, Dattilo and Scoglio Faraglione. Although subject to remarkable fluctuations (50 nesting pairs in 2007 vs. 20-22 in 2008), the colony of Alicudi in recent decades has experienced a positive trend (from 28-30 pairs counted in the 1990s to the current 56-60), in contrast to the decline detected for Salina and Panarea. The whole consistence of the Aeolian populations is estimated at 114-126 pairs, equal to 0.8% of the global population.

In mid-July, females lay 2-3 eggs at 1-2 day intervals. The care of the chicks is in charge to the female, while the male provides food; both intervene instead to defend the nest from any intruders, who are vigorously attacked, even if they are large birds.

Above, an adult of «dark» phenotype; below, a juvenile of «light» phenotype.



Hatching occurs in late August and the chicks leave the nest after 40 days; the average number of young fledged in the Alicudi colony is 1.2 per nest (with a minimum of 0.37 juv./nest in 2005 and a maximum of 1.8 in 2000) and is slightly lower than in other Italian sites. During this period, juveniles feed on small or medium-sized migrants, especially passerines, which are preyed by adults with elaborate collective hunting strategies and even far from the colonies.

Considering a requirement of 14-16 kg per pair with nestlings during the breeding period and assuming an average weight of 25 g per prey, it can be estimated that nearly 80,000 migrant birds are annually intercepted at Aeolian colonies. Such a number might seem huge, but in reality, prey consumption by the whole global population of *Falco eleonorae* is to just 0.1% of the passerines that annually cross the Mediterranean during the migration. In the pre-reproductive period, however, the species is predominantly insectivorous. In the Aeolian colonies, beetles and winged ants are the main preys, and the latter are consumed by adults and juveniles also at the end of the breeding season (after the first autumn rains), when they swarm in large numbers from anthills. A case of necrophagy, that represents an unusual behaviour for this species, has been also documented.
Colony abandonment and return to the wintering areas (Madagascar and surrounding islands) occurs in the last weeks of October. Some wintering falcons were observed in February 1999 on Filicudi, but it should be considered an exceptional event.

Checklist of resident/breeding birds of the Aeolian Islands

*extinct **irregular or not confirmed breeding

Common rock patridge *Alectoris graeca* *
Quail *Coturnix coturnix* **
Cory's shearwater *Calonectris diomedea*
Mediterranean shearwater *Puffinus yelkouan* **
Mediterranean storm petrel *Hydrobates pelagicus*
Common buzzard Buteo buteo
Lesser kestrel *Falco naumanni* **
Kestrel *Falco tinnunculus*
Eleonora's falcon *Falco eleonorae*
Peregrine falcon *Falco peregrinus*
Common moorhen *Gallinula chloropus*
Mediterranean yellow-legged gull *Larus michahellis*
Rock dove *Columba livia*
Common wood pigeon *Columba palumbus*
Eurasian collared dove *Streptopelia decaocto*
European turtle dove *Streptopelia turtur* **
Barn owl *Tyto alba*
European scops owl *Otus scops*
Little owl *Athene noctua* **
Common swift *Apus apus*
Pallid swift *Apus pallidus*
Alpine swifr *Tachymarptis melba*
European bee-eater *Merops apiaster*
European roller *Coracias garrulus* **
Eurasian crag martin *Ptyonoprogne rupestris*
Common house martin *Delichon urbica*
Red-rumped swallow *Cecropis daurica* **
Grey wagtail *Motacilla cinerea* **
White wagtail *Motacilla alba* **
Eurasian wren *Troglodytes troglodytes*
Common stonechat *Saxicola torquatus*
Blue rock thrush *Monticola solitarius*
Common blackbird *Turdus merula*
Cetti's warbler *Cettia cetti*
Zitting cisticola *Cisticola juncidis*
Eurasian blackcap *Sylvia atricapilla*
Spettacled warbler *Curruca conspicillata*
Dartford warbler *Curruca undata*
Eastern subalpine warbler *Curruca cantillans*
Sardinian warbler *Curruca melanocephala*
Spotted flycatcher *Muscicapa striata*
Eurasian blue tit *Cyanistes caeruleus* **
Eurasian great tit *Parus major* **
Woodchat shrike *Lanius senator* **
Eurasian magpie *Pica pica* **
Hooded crow *Corvus cornix*
Raven *Corvus corax*
Sparrow *Passer italiae x hispaniolensis*
Eurasian tree sparrow *Passer montanus*
Rock sparrow *Petronia petronia* **
African golden-weaver *Ploceus subaureus* **
Chaffinch *Fringilla coelebs*
European serin *Serinus serinus*
European greenfinch *Chloris chloris*
European goldfinch *Carduelis carduelis*
Eurasian linnet *Linaria cannabina*
Cirl bunting *Emberiza cirlus*
Rock bunting *Emberiza cia*
Corn bunting *Emberiza calandra* **

The Raven *Corvus corax*, the largest representative of the family Corvidae in Europe, shows a negative trend. This species was common and widespread in the Aeolian Islands until the 1990s, when the highest population density at global level was recorded: the territory of a pair was estimated between 2.5 and 4 km², ten times smaller than the surface generally occupied in larger islands or continental areas. The local overpopulation was likely related to the absence of territorial competition with large raptors and also to the availability of food, easily found in open waste dumps. The gradual closure of these latters – currently the waste is transferred to the mainland – caused a demographic collapse, but it is still possible to see groups of several individuals whose behaviour is usually characterized by marked sociality and complex intraspecific interactions. The species shows a remarkable fidelity to the nesting site, which is occupied from January or February. Laying (4-6 eggs) occurs in early spring and is often asynchronous, so the chicks have differential development, leaving the nest at different times.

Also the Mediterranean yellow-legged gull *Larus michahellis* had a noticeable expansion in the past due to the proliferation of open waste dumps, but its populations remained more or less stable after the environmental conditions have changed. Their colonies range from 5-10 to over 100 pairs and the whole Aeolian population is estimated about 1,000 pairs.

a) Raven *Corvus corax*, b) Mediterranean yellow-legged gull *Larus michahellis*, c) a group of flamingos *Phoenicopterus roseus* in the beach of Stromboli, October 2018, d) Common buzzard *Buteo buteo* and (behind) Kestrel *Falco tinnunculus* are the most common raptors in the archipelago.

Panarea, a hotspot for raptor migration

Long-term researches carried out by the late Michele Panuccio and other ornithologists, along with monitoring surveys done by LIPU volunteers during the last two decades, have highlighted the considerable importance of Panarea for raptor migration and the island's role as western tip of the route across the Strait of Messina. The largest number of recorded individuals belong to the Marsh harrier *Circus aeruginosus* (200-500 sightings in a month) and the Honey buzzard *Pernis apivorus* (from 1200 to 4650).

Both migrate mainly during daylight hours and cover long distances (up to 400 km in a day for the honey buzzard), taking advantage of thermal updrafts that occur in proximity of the island and using this latter as "stepping stones" to gain a proper altitude to flight. The gregarious behaviour of these raptors could have been stimulated by the need to locate thermal currents: spotting a group is easier than spotting single individuals indeed.

In spring, raptors reach Panarea from the southeast and continue in a northeast direction. About 15% of birds pass over the sea to the east of the island, continuing toward Stromboli, while only rarely individuals have been observed resting or hunting (mostly marsh harriers).

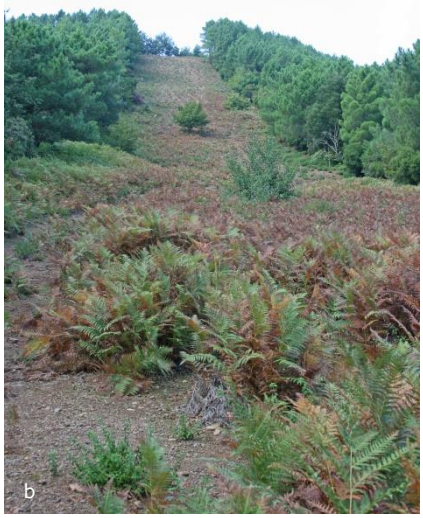
Transit is mainly concentrated in the central hours. The peak of transit depends from the species: the first half of May (70% of sightings) for the honey buzzard, the first half of April for the marsh harrier, with an initial predominance of adult males, followed only later by females and immature individuals.

The situation is reversed during the autumn migration: marsh harriers, which amount to 75% of the raptors recorded, arrive on the island in the late morning and with the occurrence of westerly quadrant winds; contrariwise, honey buzzards account for only 20% and are mostly immature, as adults seem to prefer the route along the Calabrian Apennines. The total number of individuals observed is significantly lower than in spring, and the period of transit also seems shorter (mainly concentrated in early September).

Almost all raptors crossing the island are protected and included in Annex 1 of EU Directive 09/147. Although it belongs to the same migratory route, Panarea offers to these magnificent animals a better welcome than the one they have in the Strait of Messina, where unfortunately poaching episodes are still frequent.

Migrants include several aquatics and shorebirds, for which the two coastal lagoons (Punta Lingua at Salina and Pantano dell'Istmo at Vulcano) represent the only suitable habitats for stopovers during the crossing of the Tyrrhenian Sea. In particular, the latter site is widely covered by the reed *Phragmites australis* that provides a suitable refuge.

Some species observed in the Pantano dell'Istmo, Vulcano: a) Shelduck *Tadorna tadorna*, b) Glossy ibis *Plegadis falcinellus*, c) Eurasian coot *Fulica atra*, d) Garganey *Spatula querquedula*.



The Dormouse *Glis glis* in Sicily is a typical species of montane woodland habitats. Hence, its occurrence on Salina sounds surprising in the faunal context of the Aeolian Islands. Recent genetic surveys have indicated that this population belongs to a lineage found in Sicily and Calabria, but the time of introduction remains unknown. Based on the intense vocalizations that can be heard in summer nights, particularly in the eastern and northern slopes of the Monte Fossa delle Felci-Monte Rivi complex, its density seems quite high. However, there is strong competition with *Rattus rattus*: dormouses attempted (and failed) to occupies only one out of 25 artificial nest boxes placed in 2003 within one hectare of chestnut forest, while the others were quickly populated by rats. The few available morphometric data show that the length of the hind leg is greater than the average known for Sicilian specimens; this could be interpreted as adaptation to the life in rocky environment, as a consequence of the fires that in the past often affected the island, but also to competition with the rat.

a) Dormouse *Glis glis*, and b) its habitat on the top of Salina.

Another member of the family Gliridae, the Garden dormouse *Eliomys quercinus* is known to occur on Lipari; the local population has been referred to an endemic subspecies whose taxonomic value appears doubtful. The last sightings date back to the 1990s, and despite intensive research during the past decades, its presence could not be confirmed.

The Monk Seal: a comeback story?

The first reports of the occurrence of the Monk seal *Monachus monachus* in the Aeolian Islands were reported by Lazzaro Spallanzani in the late 18th century and by the captain William H. Smyth, who in the early 19th century wrote: "*on the western shore, between the Points of Stimpaniata and Perciata, is a curious and astonishing grotto* [...] *in one of the recesses we found several seals, which we attacked, but without success*". This grotto is known as Bue Marino, in the western coast of the island of Filicudi.

Based on the tells from elderly islanders, an individual occurring in the same site was killed by a local fisherman in 1930s.
70 years later (October 30, 2000) some fishermen have seen a Monk seal 4 miles off the island of Salina.
In late October 2022, an individual was observed for five consecutive days near the islet of Strombolicchio. The sightings occurred mainly during the early morning and afternoon hours. The length of this individual was estimated between 1.5 and 2.5 meters, while the mantle coloration was described as dark gray with a dorsal lighter area. During interviews with local fishermen, ISPRA researchers collected also accounts of other sightings of monk seals near Stromboli in spring 2019.
Furthermore, positive results of eDNA analysis from seawater samples would confirm a frequentation of the archipelago by the species in winter 2021.

Some photograms of the Monk seal (probably a female) near Strombolicchio, October 30, 2022

The threatened endemic Aeolian lizard *Podarcis raffonei*

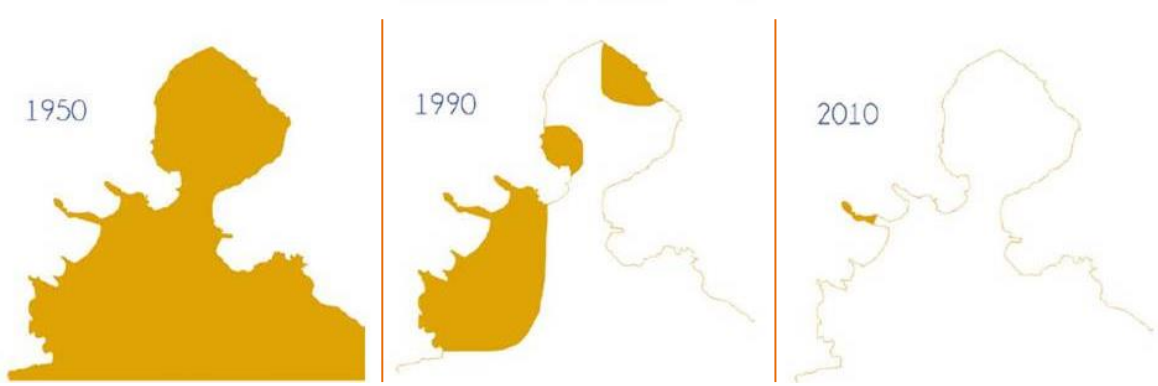
Between late 19th century and the second half of 20th century, a great number of "races" has been described for many melanistic (or hyperchromatic) lizard populations of small Mediterranean islands.
In the 1950s, the German herpetologist Robert Mertens has studied those of the Aeolian Archipelago, and referred some of them to new subspecies of the Italian wall lizard *Podarcis siculus* or, in the case of Vulcano, the Sicilian wall lizard *Podarcis waglerianus*.
Genetic investigations carried out since the 1990s – initially based on electrophoretic and successively on molecular analysis – pointed out that some of these populations belong to a distinct species, exclusively occurring in the archipelago.
At the same time, these investigations outlined a dramatic scenario: the species is strictly localized on three islets (Strombolicchio, Scoglio Faraglione and La Canna) and on a small area of Vulcano, where it shows a fast decline due to the competition with the Italian wall lizard (that conversely seems favoured by the increasing anthropogenic disturbance on the island).

Above, male of the Aeolian lizard from Strombolicchio (*Podarcis raffonei* ssp. *raffonei*); below, male from Scoglio Faraglione (*P. raffonei* ssp. *alvearioi*) and the latter islet.

Furthermore, hybridization and/or genetic introgression events with *P. siculus* have been documented for Lipari, Vulcano and perhaps Alicudi, while these processes are not involving the islets' populations, whose isolation prevent the contact between the two lizard species. As expected, however, due to their small size and the lacking of gene flow, the microinsular populations show a very low genetic variability. Moreover, that of Strombolicchio belongs to a distinct, exclusive subspecies, well characterized both from morphological and genetic point of view.

Recent estimates assess the occurrence of about 500 individuals on Strombolicchio, 200-400 on Scoglio Faraglione and just 50-80 on La Canna. The populations found on Vulcano in the 1950s are currently extinct, and the species survives only in the promontory of Capo Grosso, where it has been discovered in 1994 by B. Lanza and P. Lo Cascio. In 2018 the size of this population has been estimated as 1,050 individuals, with an average density of 0.35 individuals/m^2; however, is still unclear the rate of pure and hybridized *P. raffonei*. The species currently occurs at global level on a whole surface of about 2 ha. Hence, the Aeolian lizard is classified as Critically Endangered (CR) with the criteria B1ab(v)+2ab(v) in the "IUCN Red List of threatened species", but unfortunately it was not yet included among the priority species of the EU Directive 92/43.

The biology and ecology of *Podarcis raffonei* have been studied mostly on the islets, where it shows the typical adaptations of the lizards to the micro-insular environments: for instance, the diet includes a large amount of ants and plant matter, but also remains of birds preyed by the Eleonora's falcon and even the scarce undigested content of the pellets of raptors and gulls.



Above, map documenting the decline of the Aeolian lizard on Vulcano during the last 70 years; left, a subadult from Strombolicchio foraging on *Daucus* inflorescence; below, two lizards feeding on the remains of a prey of Eleonora's falcon at Scoglio Faraglione.


Podarcis raffonei from Strombolicchio

STAL, a conservation project for the Aeolian lizard

Since 2022, the conservation project STAL (Save The Aeolian Lizard) carried out a 3-years captive breeding program with some adults from Strombolicchio and Scoglio Faraglione islets. The new-born individuals will be released on three islets that are not (yet) inhabited by lizards but where geomorphological, biological and ecological features are suitable to support small populations. The aim of the project is to increase the number of sites occupied by the Aeolian lizard and, consequently, to minimize the risk of extinction for this species.
The project is managed by Nesos and supported by the foundations MAVA, Prince Albert II of Monaco and Blue Marine, and by the NGOs Initiative PIM and SMILO. At the Nesos office in Lipari town it is possible to have information on the natural history and the conservation of this species, as well as to visit the "lizard's corner" where animals are hosted during the captive breeding program.

Left, Pietra del Bagno Islet (off the W coast of Lipari) is one of the selected sites where the Aeolian lizard will be reintroduced during the STAL project; right, *Malva arborea* dominates the small plant community of the islet.

Selected bibliography

Aliquò V., Leo P. & Lo Cascio P., 2006. I tenebrionidi dell'Arcipelago Eoliano: nuovi dati faunistici e lineamenti zoogeografici con descrizione di una nuova specie di *Nalassus* Mulsant, 1854 (Coleoptera, Tenebrionidae). *Naturalista siciliano* 30 (2): 69-90.

Arena G.A.M., 1982. *L'economia delle Isole Eolie dal 1544 al 1961*. Tipografia Samperi, Messina, 80 pp.

Aretano R., Petrosillo I., Zaccarelli N., Semeraro T. & Zurlini G., 2013. People perception of landscape change effects on ecosystem services in small Mediterranean islands: a combination of subjective and objective assessment. *Landscape & Urban Planning* 112: 63-73.

Arnone M., Lo Cascio P. & Nistri A., 2001. I popolamenti a Scarabaeoidea delle Isole Eolie (Mar Tirreno) (Insecta Coleoptera). *Naturalista siciliano* 25 (1-2): 109-138.

Arnone M., Lo Cascio P. & Grita F., 2014. Un nuovo *Firminus* delle Eolie (Coleoptera Melolonthidae Rhizotroginae). *Naturalista siciliano* 38 (2): 339-354.

Arrighi S., Tanguy J.C. & Rosi M., 2006. Eruptions of the last 2200 years at Vulcano and Vulcanello (Aeolian Islands, Italy) dated by high-accuracy archeomagnetism. *Physic of the Earth & Planetary Interiors* 159: 225-233.

Bacci G.M., Martinelli M.C., Ollà A., Sardella A., Vanaria M.G. & Zavettieri G., 2009. *Guida archeologica delle Isole Eolie*. Regione Siciliana, Assessorato BB.CC.AA. e P.I., Palermo, 127 pp.

Barbagallo C., Brullo S. & Signorello P., 1983. Note fitosociologiche sulla vegetazione delle Isole Eolie. *Bollettino dell'Accademia gioenia di Scienze naturali* 16 (321): 7-16.

Barbera G., Cullotta S., Rossi-Doria I., Rühl J. & Rossi-Doria B., 2009. *I paesaggi a terrazze in Sicilia. Metodologie per l'analisi, la tutela e la valorizzazione*. ARPA Sicilia, Palermo, 532 pp.

Bartolo G., Brullo S., Minissale P. & Spampinato G., 1990. Contributo alla conoscenza dei boschi a *Quercus ilex* della Sicilia. *Acta botanica malacitana* 15: 203-215.

Bergeat A., 1900. Die Äolischen Inseln. *Abhandlungen der Mathematisch-Physikalischen Klasse der Königlich Bayerische Akademie der wissenschaften* 20: 1-274.

Bonfiglio L. & Latino M.T., 1988. Primo rinvenimento di un vertebrato fossile (*Testudo* cfr. *hermanni*) nell'isola di Lipari (Isole Eolie, Messina, Sicily) (Reptilia, Testudinidae). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano* 127 (3-4): 301-308.

Bosman A., Chiocci F.L. & Romagnoli C., 2009. Morpho-structural setting of Stromboli volcano revealed by high-resolution bathymetry and backscatter data of its submarine portions. *Bulletin of Volcanology* 71: 1007.

Brancati V., Maraini F., Simili M., 1951. *Volto delle Eolie*. Flaccovio, Palermo, 75 pp.

Brullo S. & Grillo N., 1985. Le associazioni psammofile effimere dei *Malcomietalia* rinvenute in Sicilia. *Bollettino dell'Accademia gioenia di Scienze naturali* 18 (325): 271-282.

Brullo S. & Minissale P., 2002. Il gruppo di *Dianthus rupicola* Biv. nel Mediterraneo centrale. *Informatore botanico italiano* 33 (2): 537-542.

Brullo S. & Pavone P., 1981. Chromosome numbers in the Sicilian species of the genus *Limonium* Miller (Plumbaginaceae). *Anales del Jardin Botánico de Madrid* 37 (2): 535-555.

Brullo S. & Signorello P., 1984. *Silene hicesiae*, a new species from Aeolian islands. *Willdenowia* 14: 141-144.

Brullo S., Scelsi F. & Spampinato G., 1997. *Aristido caerulescentis-Hyparrhenion hirtae*, alleanza nuova della classe *Lygeo-Stipetea* a distribuzione sud mediterraneo-macaronesica. *Fitosociologia* 32: 189-206.

Brullo S., Scelsi F. & Spampinato G., 1998. Considerazioni sintassonomiche sulla vegetazione perenne pioniera dei substrati incoerenti dell'Italia meridionale e Sicilia. *Itinera Geobotánica* 11: 403-424.

Brullo S., Catara S., Cristaudo A.E., Lo Cascio P. & Salmeri C., 2016. Note tassonomiche e biosistematiche su *Anthemis aeolica* (Asteraceae), pp. 11-12 in Domina G. & Peruzzi L. (eds.), *Riunioni scientifiche, Gruppo per la Floristica, Sistematica ed Evoluzione (Roma, 21-22 ottobre 2016)*. Società Botanica Italiana, Roma.

Brullo S., Brullo C., Cambria S., Ilardi V., Siracusa G., Minissale P. & Giusso Del Galdo G., 2022. *Ephedra strongylensis* (Ephedraceae), a new species from Aeolian Islands (Sicily). *Phytotaxa* 576 (3): 250-264.
Campostrini I., Demartin F., Gramaccioli C.M. & Russo M., 2011. *Vulcano, tre secoli di mineralogia*. Associazione micro-mineralogica italiana, Cremona, 344 pp.
Capaccioni B., Tassi F., Vaselli O., Tedesco D. & Poreda R., 2007. Submarine gas burst at Panarea Island (southern Italy) on November 3, 2002: a magmatic versus hydrothermal episode. *Journal of Geophysical Research* 112: B05201.
Capula M., 1993. Natural hybridization in *Podarcis sicula* and *P. wagleriana* (Reptilia: Lacertidae). *Biochemical Systematic & Ecology* 21 (3): 373-380.
Capula M., 2006. Population heterogeneity and conservation of the Aeolian wall lizard, *Podarcis raffonei*, pp. 23-32 in Corti C., Lo Cascio P. & Biaggini M. (eds.), *Mainland and Insular Lacertid Lizards: a Mediterranean perspective*. Firenze University Press, Firenze.
Capula M. & Lo Cascio P., 2010. *Podarcis raffonei* (Mertens, 1952), pp. 405-410 in Corti C., Capula M., Luiselli L., Razzetti E. & Sindaco R. (eds.), *Fauna d'Italia. XLV. Reptilia*. Calderini-Il Sole 24 Ore, Bologna.
Carapezza M.L., Barberi F., Ranaldi M., Ricci T., Tarchini L., Barrancos J., Fischer C., Perez N., Weber K., Di Piazza A. & Gattuso A., 2011. Diffuse CO_2 soil degassing and CO_2 and H_2S concentration in air and related hazards at Vulcano Island (Aeolian arc, Italy). *Journal of Volcanology & Geothermal Research* 207: 130-144.
Cardinale M., Lanza A., Bonnì M.L., Marsala S., Puglia A.M. & Quatrini P., 2008. Diversity of rhizobia nodulating wild shrubs of Sicily and some neighbouring islands. *Archives of Microbiology* 190: 461-470.
Chiarucci A., Guarino R., La Rosa A., Lo Cascio P., Médail F., Pasta S., Pavon D., Fernández-Palacios J.M. & Zannini P., 2021. Species-area relationship and small island effect of vascular plant diversity in a young volcanic archipelago. *Journal of Biogeography* 48 (11): 2919-2931.
Conte L., Troìa A. & Cristofolini G., 1998. Genetic diversity in *Cytisus aeolicus* Guss. (Leguminosae), a rare endemite of the Italian flora. *Plant Biosystems* 132 (3): 239-249.
Corso A. & Gustin M., 2009. Primi dati su parametri riproduttivi del falco della regina *Falco eleonorae* in Sicilia. *Alula* 16 (1-2): 208-210.
Corso A. & Gustin M., 2012. Second-calendar-year Eleonora's Falcons attending breeding colonies in Sicily. *British Birds* 105: 738-742.
Cucinotta F. & Pieroni A., 2018. "If you want to get married, you have to collect *virdura*": the vanishing custom of gathering and cooking wild food plants on Vulcano, Aeolian Islands, Sicily. *Food, Culture & Society* 21 (4): 539-567.
Dawson H., 2016. Per un'archeologia comparata delle isole: dalla teoria alla pratica, pp. 23-36 in in Cazzella A., Guidi A. & Nomi F. (eds.), *Ubi minor… le isole minori del Mediterraneo centrale dal Neolitico ai primi contatti coloniali. Scienze dell'Antichità* 22 (2).
De Castro O., Vela E., Vendramin G.G., Gargiulo R. & Caputo P., 2015. Genetic structure in the *Genista ephedroides* complex (Fabaceae) and implications for its present distribution. *Botanical Journal of the Linnean Society* 177 (4): 607-618.
Delaugerre M., Grita F., Lo Cascio P. & Ouni R., 2012. Lizards and Eleonora's Falcon (*Falco eleonorae* Gené, 1839), a Mediterranean micro-insular commensalism. *Biodiversity Journal* 3 (1): 3-12.
Di Benedetto L., 1973. Flora di Alicudi (Isole Eolie). *Archivio botanico e biogeografico italiano* 49 (3-4): 135-162.
Di Gristina E., Domina G. & Barone G., 2021. The alien vascular flora of Stromboli and Vulcano (Aeolian Islands, Italy). *Italian Botanist* 12: 63-75.
Domina G. & Spallino R.E., 2007. *Paraserianthes lophanta* (Mimosaceae) nell'isola di Pantelleria e nell'arcipelago delle isole Eolie. *Quaderni di Botanica ambientale e applicata* 18: 303-304.
Failla M.C. & Messina A., 1974. *Ectobius* (Blattodea, Ectobiidae) dell'Arcipelago Eoliano e dell'isola di Ustica. *Animalia* 1 (1-3): 217-233.
Fattorini S., 2010. The influence of geographical and ecological factors on island beta diversity patterns. *Journal of Biogeography* 37: 1061-1070.

Fattorini S., 2011. Influence of island geography, age and landscape on species composition in different animal groups. *Journal of Biogeography* 38: 1318-1329.
Fattorini S., 2011. Biogeography of tenebrionid beetles (Coleoptera: Tenebrionidae) in the circum-Sicilian islands (Italy, Sicily): multiple biogeographical patterns require multiple explanations. *European Journal of Entomology* 108: 659-672.
Favilli L., 2017. Osservazioni sulla fauna a Lepidotteri Ropaloceri delle Isole Eolie (Sicilia) (Lepidoptera: Papilionoidea). *Bollettino della Società entomologica italiana* 149 (3): 131-134.
Ferrer J., 2015. Revisión del género *Leptoderis* Billberg, 1820 y comentarios sobre el origen, composición, anatomía y necrofagia de la tribu Elenophorini (Coleoptera, Tenebrionidae). *Boletín de la Sociedad entomológica aragonesa* 57: 19-38.
Ferro G., 2005. Nuovi dati sulla flora e sulla vegetazione dei coltivi e degli incolti di Lipari (Isole Eolie). *Quaderni di Botanica ambientale e applicata* 15: 21-39.
Ferro G., 2009. *Erysimum brulloi* (Brassicaceae), a new species from the Aeolian Archipelago (Sicily). *Flora mediterranea* 19: 297-302.
Ferro G. & Furnari F., 1968. Flora e vegetazione di Stromboli (Isole Eolie). *Archivio botanico e biogeografico italiano* 12 (1-2): 21-45; (3): 59-85.
Ferro G. & Furnari F., 1970. Flora e vegetazione di Vulcano (Isole Eolie). *Pubblicazioni dell'Istituto di Botanica dell'Università di Catania* [1970]: 1-66.
Ferro G. & Ladero-Alvarez M., 1996. Osservazioni fitosociologiche sulle praterie a *Brachypodium retusum* delle Isole Eolie (Sicilia). *Quaderni di Botanica ambientale e applicata* 7: 99-105.
Ficetola G.F., Silva-Rocha I., Carretero M.A., Vignoli L., Sacchi R., Melotto A., Scali S. & Salvi D., 2021. Status of the largest extant population of the critically endangered Aeolian lizard *Podarcis raffonei* (Capo Grosso, Vulcano Island). *PLOS One* 16 (6): e0253631.
Fiore M., Violani C. & Zava B., 1992. Chirotteri delle Isole circumsiciliane. I – Vulcano (Eolie). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano* 132: 169-180.
Focarile A., 1972. Ricerche entomologiche nell'arcipelago delle Eolie e nell'isola di Ustica (Sicilia). II. La coleotterofauna dello stagno salmastro di Punta Lingua nell'Isola di Salina. *Memorie della Società entomologica italiana* 51: 19-37.
Forconi V. & Guidi S. (eds.), 2013. *Frutti dimenticati e biodiversità recuperata. Il germoplasma frutticolo e viticolo delle agricolture tradizionali italiane. Casi studio: Isole di Sicilia, Lombardia*. Quaderni Natura e Biodiversità 5/2013, ISPRA, 147 pp.
Gaudin C.T. & Pirajno di Mandralisca E., 1860. Contributions à la flore fossile italienne. Cinquième mémoire. Tufs volcaniques de Lipari. *Mémoires de la Société helvetique des Sciences naturelles* 18: 3-11.
Giani S., 1987. *Le piante medicinali delle Isole Eolie*. Pungitopo, Marina di Patti, 103 pp.
Giuffrè M. & Nicora N., 1999. Borghesia mercantile e marineria di Salina, pp. 25-42 in Todesco S. & Gullo R. (eds.), *I sentieri di Didyme. Un percorso antropologico*. Regione Siciliana, Palermo.
Giusti F., 1973. Notulae Malacologicae. XVIII. I Molluschi terrestri e salmastri delle Isole Eolie. *Lavori della Società italiana di Biogeografia* 3: 113-306.
Giusti F., Manganelli G. & Crisci J.V., 1992. A new problematical Hygromiidae from the Aeolian Islands (Italy) (Pulmonata: Helicoidea). *Malacologia* 34 (1-2): 107-128.
Guarino R., Cerra D., Zaia R., Chiarucci A., Lo Cascio P., Rocchini D., Zannini P. & Pasta S., 2023. Remote sensing reveals fire-driven facilitation of a C_4 rhizomatous alien grass on a small Mediterranean volcanic island. *Biogeosciences Discussions*, doi: 10.5914/bg-2023-19.
Gussone G., 1832-1834. *Supplementum ad Florae Siculae Prodromum, quot et specimen florae insularum Siciliae ulteriori adjacentum*. Regia Typographia, Neapoli, I [1832], IX+166 pp.; II [1834], 71 pp.
Habsburg Lothringen L.S., 1894. *Die Liparischen Inseln. Achtes Heft: Allgemeiner theil*. H. Mercy, Praha, X+159 pp.
Hilpold A., Schönswetter P., Susanna A., Garcia-Jacas N. & Vilatersana R., 2011. Evolution of the central Mediterranean *Centaurea cineraria* group (Asteraceae): evidence for relatively recent, allopatric diversification following transoceanic seed dispersal. *Taxon* 60 (2): 528-538.

Hürner H., Krystufek B., Sarà M., Ribas A., Ruch T., Sommer R., Ivashkina V. & Michaux J.R., 2010. Mitochondrial phylogeography of the edible dormouse (*Glis glis*) in the western Palaearctic region. *Journal of Mammalogy* 91 (1): 233-242.
Johnston-Lavis H.J. (ed.), *The South Italian Volcanoes, being an account of the excursion to them made by English and other geologists in 1889 under the auspices of the Geologist's Association of London with papers on the different localities by Messrs. Johnston-Lavis, Platania, Sambon, Zezi and Madame Antonia Lavis, including the bibliography of the volcanic districts and 16 plates*. F. Furchheim, Naples, 103 pp.
Jutzeler D., Grillo N. & De Bros E., 1995. Une visite à l'île de Vulcano (dans les îles Eoliennes, Sicile) pour *Hipparchia leighebi* (Kudrna, 1976) (Lepidoptera: Nymphalidae, Satyrinae). *Linneana Belgica* 15 (3): 119-126.
Kahmann H., 1960. Der Gartenschläfer auf der Insel Lipari (Provinz Messina), *Eliomys quercinus liparensis* n. subsp., und die Gartenschläfer-Unterarten im Westteil des Mittelmeerraumes. *Zoologischer Anzeiger* 164: 172-185.
King R. & Young S., 1979. The Aeolian Islands: birth and death of an human landscape. *Erdkunde* 33: 193-204.
Kudrna O., 1976. Two new taxa of the genus *Hipparchia* Fabricius. *Atalanta* 7: 168-171.
Laghetti G., Olita G., Hammer K. & Perrino P., 2007. Multicrop collecting expeditions in Aeolian Archipelago (Italy). *Plant Genetic Resources Newsletter* 128: 26-34.
La Greca G., 2011. *Le giornate di Filicudi. 26 maggio 1971, la prima rivolta contro la mafia in Sicilia*. Centro Studi Eoliano, Lipari, 205 pp.
La Greca G., 2016. *Passolina, uva passa e malvasia. L'economia vitivinicola delle Eolie*. Centro Studi Eoliano, Lipari, 166 pp.
Lentini F., Giani S. & Amenta R., 1995. L'uso popolare delle piante nelle Isole Eolie (Sicilia). *Acta Technologiae et Legis Medicamenti* 6 (3): 351-355.
Lo Cascio P., 2000. Note sul Falco della regina, *Falco eleonorae*, nell'Arcipelago Eoliano (Sicilia). *Rivista italiana di Ornitologia* 69 (2): 187-194.
Lo Cascio P., 2004. Preliminary observations on the insect fauna associated with two threatened plant species, *Bassia saxicola* (Guss.) A. J. Scott and *Cytisus aeolicus* Guss., on the Aeolian Islands (Southern Tyrrhenian Sea). *Naturalista siciliano* 28 (3-4): 1155-1169.
Lo Cascio P., 2006. Aspetti ecologici e problemi di conservazione di una popolazione di *Podarcis raffonei* (Mertens, 1952) (Reptilia: Lacertidae). *Naturalista siciliano* 30 (3-4): 495-521
Lo Cascio P., 2007. Nuovi dati sulla nidificazione di *Hydrobates pelagicus* nell'Arcipelago Eoliano (Tirreno meridionale). *Rivista italiana di Ornitologia* 77 (1): 59-60.
Lo Cascio P., 2010. Attuali conoscenze e misure di conservazione per le popolazioni relitte dell'endemica lucertola delle Eolie, *Podarcis raffonei* (Squamata Sauria). *Naturalista siciliano* 34 (3-4): 295-317.
Lo Cascio P., 2012. Il pantano dell'Istmo di Vulcano (Isole Eolie): dati storici e avifaunistici su un ecosistema umido costiero circumsiciliano. *Naturalista siciliano* 36 (1-2): 55-76.
Lo Cascio P., 2014. *"Cose diverse dalle vulcaniche". Le Eolie dell'Ottocento esplorate da Mandralisca e altri naturalisti*. Pungitopo, Gioiosa Marea, 170 pp.
Lo Cascio P., 2016. Marine birds of the Aeolian Archipelago, South Tyrrhenian Sea: present status and conservation, pp. 96-99 in Yésou P. *et alii* (eds.), *Conservation of marine and coastal birds in the Mediterranean. Proceedings of the UNEP-MAP-RAC/SPA Symposium (Hammamet, 20-22 February 2015)*. RAC/SPA-AAO-BirdLife Tunisia-Medmaravis.
Lo Cascio P., 2017. *Luoghi e natura di Sicilia. 1. Le Isole Eolie*. Danaus, Palermo, 320 pp.
Lo Cascio P., 2020. Seasonal occurrence and abundance of dung beetles on a small Mediterranean island. *Naturalista siciliano* 44 (1-2): 289-294.
Lo Cascio P. & Capula M., 2011. Does diet in lacertid lizard reflect prey availability? Evidence for selective predation in the Aeolian wall lizard, *Podarcis raffonei* (Mertens, 1952) (Reptilia, Lacertidae). *Biodiversity Journal* 2 (2): 89-96.

Lo Cascio P. & Corti C., 2006. The micro-insular distribution of the genus *Podarcis* within the Aeolian Archipelago: historical vs. palaeogeographical interpretation, pp. 87-98 in Corti C., Lo Cascio P. & Biaggini M. (eds.), *Mainland and Insular Lizards: a Mediterranean Perspective*. Firenze University Press, Firenze.
Lo Cascio P. & Grita F., 2010. First record of the spider family Selenopidae in Italy (Araneae). *Naturalista siciliano* 34 (3-4): 385-389.
Lo Cascio P. & Massa B., 2023. Spatial shifts within the Eleonora's falcon reproductive sites of the Aeolian Islands (Tyrrhenian Sea). *Naturalista siciliano* 46 (2): 231-232.
Lo Cascio P. & Masseti M., 2007. First evidence of the occurrence of the Pygmy white-toothed shrew, *Suncus etruscus* (Savi, 1821), on the island of Lipari, Aeolian Archipelago (Italy). *Mammalia* 71 (4): 187-188.
Lo Cascio P. & Pasta S., 2000. Phoinikodes, l'isola delle palme. *Quaderni del Museo archeologico regionale eoliano "L. Bernabò Brea"* 3: 127-129.
Lo Cascio P. & Pasta S., 2003. *Cephalanthera rubra* (L.) L.C.M. Richard a Salina (Isole Eolie) (Orchidaceae). *Naturalista siciliano* 27 (3-4): 323-324.
Lo Cascio P. & Pasta S., 2020. Bio-ecological survey on the vascular flora of the satellite islets of the Aeolian Archipelago (south-eastern Tyrrhenian Sea, Italy), pp. 21-46 in La Mantia T., Badalamenti E., Carapezza A., Lo Cascio P. & Troia A. (eds.), *Life on Islands. 1. Biodiversity in Sicily and surrounding islands. Studies dedicated to Bruno Massa*. Danaus, Palermo.
Lo Cascio P. & Ponel P., 2022. The beetle fauna of the coastal lagoon of Punta Lingua (Salina Island, Aeolian Archipelago), half century later. *Onychium* (n.s.) 15: 79-88.
Lo Cascio P. & Sciberras A., 2020. "Cold-blooded" travellers around Sicily: how introductions and extinctions have shaped the recent herpetofauna of circum-Sicilian and Maltese islands, pp. 335-390 in La Mantia T., Badalamenti E., Carapezza A., Lo Cascio P. & Troia A. (eds.), *Life on Islands. 1. Biodiversity in Sicily and surrounding islands. Studies dedicated to Bruno Massa*. Danaus, Palermo.
Lo Cascio P. & Sparacio I., 2010. A new *Anthaxia* from the Aeolian Islands (Coleoptera, Buprestidae). *Fragmenta entomologica* 42 (2): 499-506.
Lo Cascio P., Pasta S., Rossi P.L., Tranne C.A. & De Luca M., 2002. *Fossili vegetali in depositi vulcanici delle isole Eolie e di Linosa. Implicazioni paleoecologiche*. Quaderni del Centro Studi, Aton, Roma, 42 pp.
Lo Cascio P., Biaggini M. & Corti C., 2014. Lisca Nera lizards: history of an extinction through zoology and literature, pp. 63-75 in Capula M. & Corti C. (eds.), *Scripta Herpetologica. Studies on Amphibians and Reptiles in honour of Benedetto Lanza*. Belvedere, Latina.
Lo Cascio P., Grita F., Guarino L. & Speciale C., 2014. A little is better than none: new insights into the natural history of the Aeolian wall lizard *Podarcis raffonei* from La Canna stack (Squamata Sauria). *Naturalista siciliano* 38 (2): 203-214.
Lo Cascio P., Ponel P. & Altadonna G., 2022. Diversity and distribution of beetles in a Mediterranean volcanic archipelago: an updated checklist of the Coleoptera of the Aeolian Islands (Sicily, Italy). *Biodiversity Journal* 13 (3): 531-585.
Lojacono[-Pojero] M., 1878. *Le Isole Eolie e la loro vegetazione con enumerazione delle piante spontanee vascolari*. Stamperia G. Lorsnaider, Palermo, 140 pp.
Lucchi F., Peccerillo A., Keller J., Tranne C.A. & Rossi P.L. (eds.), 2013. *The Aeolian Islands Volcanoes*. Geological Society Memoir No. 37, The Geological Society, London, 520 pp.
Madonia P., 2006. La distribuzione areale della vegetazione come indicatore dell'attività vulcanica. *Atti XV Congresso Nazionale della Società italiana di Ecologia (Torino, 12-14 settembre 2005)*, www.xvcongresso.societaitalianaecologia.org/articles/Madonia-31.pdf.
Magrini P., Cecchi B. & Lo Cascio P., 1999. Un nuovo *Ocys* italiano (Coleoptera Carabidae). *Redia* 81: 73-81.
Manni M., Coltelli M. & Martinelli M.C., 2019. Volcanic events that have marked the anthropic history of the Aeolian Islands. Annals of Geophysics 62: V008.

Martinelli M.C., 2016. Updates on the cultural and chronological framework of the prehistory and protohistory of the Aeolian Islands: from the first settlement to the end of the villages, pp. 263-279 in Cazzella A., Guidi A. & Nomi F. (eds.), *Ubi minor… le isole minori del Mediterraneo centrale dal Neolitico ai primi contatti coloniali. Scienze dell'Antichità* 22 (2).
Martinelli M.C., 2020. *Isole vicine. L'arcipelago delle Isole Eolie e le comunità umane nella preistoria mediterranea*. Edizioni di Storia e Studi sociali, Ragusa, 287 pp.
Martinelli M.C. & Lo Cascio P., 2015. *Vulcanologia: Sezione Territorio Uomo e Ambiente*. Guide del Museo Archeologico Regionale "L. Bernabò Brea", Assessorato dei Beni Culturali e dell'Identità Siciliana, Palermo, 59 pp.
Martinelli M.C., Coltelli M., Manni M., Bonizzoni L., Guglielmetti A., Oddone M. & Balestrieri M.L., 2020. Prehistorical obsidian sources in the island of Lipari (Aeolian Islands). *Open Archaeology* 6: 393-402.
Martinelli M.C., Dawson H., Lo Cascio P., Levi S. & Fiorentino G., 2021. Blowin' in the wind: settlement, landscape and network dynamics in the prehistory of the Aeolian Islands (Italy). *Journal of Mediterranean Archaeology* 34 (1): 28-57.
Massa B., Lo Cascio P., Ientile R., Canale E.D. & La Mantia T., 2015. Gli uccelli delle isole circumsiciliane. *Naturalista siciliano* 39 (2): 105-373.
Médail F., Pavon D., Lo Cascio P. & Pasta S., 2016. Sulla presenza di *Ophioglossum lusitanicum* L. nell'isola di Vulcano e aggiunte alla flora vascolare delle Isole Eolie (Sicilia nord-orientale). *Naturalista siciliano* 40 (1): 27-42.
Mellone U., Agostini N., Panuccio M. & Gustin M., 2013. La migrazione primaverile dei rapaci accipitriformi attraverso le Isole Eolie: primi dati, pp. 235-237 in Benussi E. & Perco F. (eds.), Atti XIV Convegno Italiano di Ornitologia (Trieste, 26-30 settembre 2007). *Rivista italiana di Ornitologia* 82.
Métrich N., Bertagnini A. & Pistolesi M., 2021. Paroxysms at Stromboli volcano (Italy): source, genesis and dynamics. *Frontiers in Earth Science* 9: 593339.
Minissale P., Brullo C., Brullo S., Giusso Del Galdo G. & Sciandrello S., 2013. *Bituminaria basaltica* (Fabaceae), a new species from Italy. *Phytotaxa* 98 (1): 1-15.
Mo G., Agnesi S., Lo Cascio P. & Massa B., 2023. Dati storici e recenti sulla presenza della foca monaca nelle Isole Eolie (Tirreno meridionale, Sicilia). *Naturalista siciliano* 46 (2): 99-106.
Moltoni E. & Frugis S., 1967. Gli uccelli delle Isole Eolie (Messina, Sicilia). *Rivista italiana di Ornitologia* 37 (2-3): 91-234.
Päckert M., Giacalone G., Lo Valvo M. & Kehlmaier C., 2019. Mitochondrial heteroplasmy in an avian hybrid form (*Passer italiae*: Aves, Passeriformes). *Mitochondrial DNA (B)* 4 (2): 3809-3812.
Panuccio M., Agostini N. & Mellone U., 2005. Autumn migration strategies of honey buzzards, black kites, marsh and Montagu's harriers over land and over water in the Central Mediterranean. *Avocetta* 29: 27-32.
Pasta S. & La Mantia T., 2013. Species richness, biogeographic and conservation interest of the vascular flora of the satellite islands of Sicily: patterns, driving forces and threats, pp. 201-238 in Cardona Pons E., Estaún Clarisó I., Comas Casademont M. & Fraga i Arguimbau P. (eds.), *Islands and plants: preservation and understanding of flora on Mediterranean islands*. Colleció Recerca 20, Institut Menorquí d'Etudis-Consell Insular de Menorca, Maò.
Pasta S. & Lo Cascio P., 2002. Contributi alla conoscenza botanica delle isole minori circumsiciliane. II. Note tassonomiche e geobotaniche sulla flora delle Isole Eolie. *Naturalista siciliano* 26 (3-4): 131-145.
Pasta S., Lo Cascio P. & Pancioli V., 1999. Sull'effettiva consistenza numerica e distribuzione delle Orchidaceae nell'Arcipelago Eoliano (Mar Tirreno meridionale). *Naturalista siciliano* 23 (3-4): 467-484.
Pasta S., Buscemi I., Crisafulli A., Giovino A., Lo Cascio P., Buord S., Guarino R. & La Mantia T., 2014. Ecologia e distribuzione di *Chamaerops humilis* L. (Arecaceae) nella Sicilia nord-orientale. *Naturalista siciliano* 38 (2): 291-306.
Pasta S., La Rosa A., Garfì G., Marcenò C., Gristina A.S., Carimi F. & Guarino R., 2020. An updated checklist of the Sicilian native edible plants: preserving the traditional ecological knowledge of century-old agro-pastoral landscapes. *Frontiers in Plant Science* 11: 338.

Pasta S. & Troia A., 2017. *Silene hicesiae*, in Pasta S., Perez-Graber A., Fazan L., Montmollin B. (de) (eds.), *The Top 50 Mediterranean Island Plants Update 2017*. IUCN/SSC/Mediterranean Plant Specialist Group, Neuchâtel.
Ponel P., Lo Cascio P. & Soldati F., 2020. A new species of *Catomus* Allard, 1876 (Coleoptera: Tenebrionidae: Helopini) from the Aeolian Archipelago (Sicily, Italy). *Zootaxa* 4743 (2): 295-300.
Rosi M., Levi S.T., Pistolesi M., Bertagnini A., Brunelli D., Cannavò V., Di Renzoni A., Ferranti F., Renzulli A. & Yoon D., 2019. Geoarchaeological evidence of Middle-Age tsunamis at Stromboli and consequences for the tsunami hazard in the southern Tyrrhenian Sea. *Scientific Reports* 9: 677.
Ricci Lucchi F., Calanchi N., Lanzafame G. & Rossi P.L., 1988. Plant-rich pyroclastic deposits of Monte S. Angelo, Lipari (Aeolian Islands). *Rendiconti della Società italiana di Mineralogia e Petrologia* 43: 1227-1251.
Richter M., 1984. Vegetationsdynamik auf Stromboli (Zur Geookologie trockenmediterraner Standorte). *Aachener Geographische Arbeiten* 16: 41-110.
Richter M. & Lingenhöhl D., 2002. Landschaftsentwicklung auf den Äolischen Inseln. *Geographische Rundschau* 54: 20-26.
Riva Sanseverino R., 2002. *Atlante sulla forma dell'insediamento: le isole minori della Sicilia. Analisi e studi sul territorio delle microisole, progetto e strategie di pianificazione*. Libreria Dante, Palermo, 191 pp.
Rizzo A.L., Federico C., Inguaggiato S., Sollami A., Tantillo M., Vita F., Bellomo S., Longo M., Grassa F. & Liuzzo M., 2015. The 2014 effusive eruption at Stromboli volcano (Italy): inferences from soil CO_2 flux and $^3He/^4He$ ratio in thermal waters. *Geophysical Research Letters* 42 (7): 2235-2243.
Rühl J. & Pasta S., 2007. Plant succession on Sicilian terraces. *Annals of Botany* 7: 111-126.
Sabatinelli G., 1976. Revisione delle specie italiane del sottogenere *Mesanoxia* Med. (Coleoptera, Scarabaeidae, Melolonthinae). *Fragmenta entomologica* 12 (2): 143-157.
Santangelo A., Croce A., Lo Cascio P., Pasta S., Strumia S. & Troìa A., 2012. Schede per una Lista Rossa della Flora vascolare e crittogamica Italiana. *Eokochia saxicola* (Guss.) Freitag & G. Kadereit. *Informatore botanico italiano* 44 (2): 428-431.
Sarà M., 2008. Quercino *Eliomys quercinus* (L., 1758), pp. 54-56 in AA.VV., *Atlante della biodiversità della Sicilia: Vertebrati terrestri*. ARPA Sicilia, Palermo.
Schär S., Menchetti M., Schifani E., Hinojosa J.C., Platania L., Dapporto L. & Vila R., 2020. Integrative biodiversity inventory of ants from a Sicilian archipelago reveals high diversity on young volcanic islands (Hymenoptera: Formicidae). *Organisms Diversity & Evolution* 20: 405-416.
Senczuk G., Colangelo P., De Simone E., Aloise G. & Castiglia R., 2017. A combination of long term fragmentation and glacial persistence drove the evolutionary history of the Italian wall lizard *Podarcis siculus*. *BMC Evolutionary Biology* 17: 6.
Solano E., Castiglia R. & Corti M., 2007. A new chromosomal race of the house mouse, *Mus musculus domesticus*, in the Vulcano Island, Aeolian Archipelago, Italy. *Hereditas* 144 (3): 75-77.
Solano E., Castiglia R. & Capanna E., 2009. Chromosomal evolution of the house mouse, *Mus musculus domesticus*, in the Aeolian Archipelago (Sicily, Italy). *Biological Journal of the Linnean Society* 96: 194-202.
Speciale C., 2021. *Human-environment dynamics in the Aeolian Islands during the Bronze Age. A paleodemographic model*. BAR International Series 3052, BAR Publishing, Oxford, 155 pp.
Stroscio S., Baviera C., Frati F., Lo Paro G. & Nardi F., 2011. Colonization of the Aeolian Islands by *Pimelia rugulosa rugulosa* Germar, 1824 (Coleoptera: Tenebrionidae) inferred from the genetic structure of populations: geological and environmental relations. *Biological Journal of the Linnean Society* 104: 29-37.
Tanguy J.-C., Le Goff M., Principe C., Arrighi S., Chillemi V., Paiotti A., La Delfa S. & Patané G., 2003. Archeomagnetic dating of Mediterranean volcanics of the last 2100 years: validity and limits. *Earth & Planetary Science Letters* 211: 111-124.
Todesco S. (ed.), 1995. *Atlante dei beni etno-antropologici eoliani*. Regione Siciliana-Assessorato BB.CC.AA. e P.I., Messina, 599 pp.
Troia A., 1997. Contributo alla conoscenza della flora delle Isole Eolie (Sicilia). *Informatore botanico italiano* 29: 262-266.

Troia A., 2012. Insular endemism in the Mediterranean vascular flora: the case of the Aeolian Islands (Sicily, Italy). *Biodiversity Journal* 3 (4): 369-374.
Troia A., Cardinale M., La Manna M., Lo Cascio P., Pasta S., Puglia A.M., Quatrini P. & Voutsinas E., 2005. Preliminary results of EOLIFE99, a project concerning the conservation of four endangered plant species of Aeolian Archipelago (South Tyrrhenian Sea, Italy). *Quaderni di Botanica ambientale e applicata* 16: 173-174.
Troia A., Raimondo F.M. & Mazzola P., 2012. Mediterranean island biogeography: analysis of fern species distribution in the system of islets around Sicily. *Plant Biosystems* 146 (3): 576-585.
Turchi A., Di Traglia F., Luti T., Olori D., Zetti I. & Fanti R., 2020. Environmental aftermath of the 2019 Stromboli eruption. *Remote Sensing* 12: 994.
Turrisi G.F., Altadonna G., Lo Cascio P., Nobile V. & Selis M., 2020. Contribution to the knowledge of Hymenoptera from the Aeolian Archipelago (Sicily), emphasizing Aculeata. *Biodiversity Journal* 11 (3): 717-750.
Valsecchi F., 1986. Due nuove specie del genere *Genista* L. nel Mediterraneo. *Bollettino della Società sarda di Scienze naturali* 25: 143-147.
Vodă R., Dapporto L., Dincă V., Shreeve T.G., Khaldi M., Barech G., Rebbas K., Sammut P., Scalercio S., Hebert P.D.N. & Vila R., 2016. Historical and contemporary factors generate unique butterfly communities on islands. *Scientific Reports* 6: 28828.
Zaia R., Pasta S., Di Rita F., Laudicina V.A., Lo Cascio P., Magri D., Troia A. & Guarino R., 2020. Staying alive on an active volcano: 80 years population dynamics of *Cytisus aeolicus* (Fabaceae) from Stromboli (Aeolian Islands, Italy). *Ecological Processes* 9: 64.

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