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Fishing using poisonous plants in Campania, Italy. A brief historical survey

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Abstract

This article delves into the historical use of poisonous plants used for fishing in Campania, Italy, from the 16th to the 19th centuries, exploring both ancient practices and more recent practices found during the era of transition to the Italian Kingdom. It describes how various plants used as ichthyotoxins, including *Cyclamen* spp., *Euphorbia* spp., *Taxus baccata*, and *Strychnos nux-vomica*, underscoring their significance in traditional fishing methods in Campania across different times. The study also examines legal and regulatory responses to this practice, noting its persistence despite changing legal frameworks. This examination sheds light on the deep-rooted tradition of using natural toxins in fishing, contributing to our understanding of cultural practices in Southern Italy.

Keywords: fishing, *chiusarana*, poisonous plants, *Euphorbia*, *Taxus*, *Strychnos*, *Cyclamen*, Campania, XVI-XIX Centuries

Riassunto

Questo articolo approfondisce l'uso storico di piante velenose per la pesca in Campania, Italia, dal XVI al XIX secolo, esplorando sia le pratiche antiche sia la transizione all'epoca del Regno d'Italia. Si prendono in considerazione diverse piante utilizzate come ittiotossiche, tra cui *Cyclamen* spp., *Euphorbia* spp., *Taxus baccata* e *Strychnos nux-vomica*, sottolineando la loro importanza nei metodi di pesca tradizionali in Campania durante un arco temporale molto esteso. Lo studio esamina anche le risposte legali e normative a questa pratica, notando la sua persistenza nonostante l'evoluzione dei quadri

giuridici. Questo esame fa luce sulla radicata tradizione dell'uso di tossine naturali nella pesca, contribuendo alla comprensione delle pratiche culturali nell'Italia meridionale.

Keywords: pesca, *chiusarana*, piante velenose, *Euphorbia*, *Taxus*, *Strychnos*, *Cyclamen*, Campania, XVI-XIX Secolo**.**

Introduction

Fishing by poisonous plants is a technique largely used throughout the world. In one of the first syntheses on this topic Greshoff (1900) recorded about 500 species, including fungi, that were used as ichthyotoxins. The seed plants represented the largest part of this list and were distributed among approximately 210 different plant families. Building on this work, Heizer (1953) showed that the use of piscicides encompassed a large geographical area, from Persia to North China and Asia extending to Indonesia, Malaysia, Japan, and Australia indicating that their use was possibly spread by cultural contacts between different ethnic groups. Europe was another large geographical area where there was an old tradition of plant piscicides, from eastern and central European countries, as Poland, Hungary, and Bosnia, to France, the British Isles, and Ireland (Svanberg & Locker, 2020). Fish poisoning was also reported from the Mediterranean region. Álvarez Arias (2003) listed 32 ichthyotoxic plants used in Spain, where this practice was already spread throughout the region in Middle Ages. The use of stunning or killing fish by plants has been also reported in Portugal (Van De Putte, 2005), Italy (Guarrera, 2005; Leto et al., 2013), and Greece (Kamen-Kaye, 1977). Regarding Greece, Heizer (1953) suggested that a report on ichthyotoxic plants could be found in the writings of Aristotle. Indeed, in *Historia animalium*, he reported the practice of using plant piscicides: "Fishes are poisoned with the plant called mullein for which reason some persons capture them by poisoning the waters of rivers and ponds […]" (Aristotle, 2002, Hist. An. VIII, XX). Quigley (1956) suggested that the entire Old World was a single diffusion area of fish poisoning knowledge, coming from Southern or Southeastern Asia, probably the focus area of this trait, whence moved to the rest of the world.

The origins of fish drugging are thought as being very remote: Béarez (1998) reported evidence of this practice from an archeological site of Ecuador dated in the first millennium. Howes (1930) described in detail the usual method in which this practice was conducted in most parts of the world: the organs of the plants containing most of piscicide substances are collected and finely crushed. Then the fragments are thrown in a part of a water body with a slow water flow and, acting on respiratory systems of the fish, produced a stupefying effect, followed by death. Less frequent is the alternative strategy, in which the toxic plant is consumed by the fish after being mixed with food. Heizer (1953) mentioned also other two strategies, (i) putting plant material in a basket that is soused deep and down in the water, or (ii) burning the plants in close vicinity to water, so that the toxic smoke spreads over the water. Plants can also be fermented or cooked before being used, or they can be thrown in the water and subsequently beaten with a stick, to allow the releasing of the toxic substances (Acevedo-Rodrìguez, 1990).

The number of plants used is so high and the species are so diverse, that many chemical constituents can be considered as responsible for the toxic effects on fish metabolism. The active ingredients range from tannins to other phenolic compounds such as isoflavonoids, alkaloids or hydrocyanic acid. Only the latter compound requires a mild heat treatment to separate it from the bark of some plants, while the others are active immediately after

crushing the leaves, rhizomes or roots. The aforementioned substances can also be toxic to humans, so the choice of plant is often linked to this crucial aspect. For example, Van Andel (2000) emphasizes that most ichthyotoxic plants used by Amerindians of Northeast Guyana contains rotenone, an isoflavone causing respiratory failure of fish, that can be safely digested by humans and is unstable in light and heat.

Fishing with ichthyotoxic plant material is also reported from Italy by Savo et al. (2013), who refers that "the use of ichthyotoxic plants for illegal fishing is frequently reported in freshwater basins, while it is rare in coastal areas". However, modern studies concerning this practice seems to be mainly focused on the Northern regions of Italy (Cornara et al., 2009), although the use of poisonous plants in fishing activities has also been noted in Southern Italy and dates to Antiquity. Here we report information on poaching with poisonous plants in Southern Italy across the centuries, focusing our research on Centuries XVI-XIX, also including the first decades of the newborn Kingdom of Italy.

Methodology

Different sources were used for drawing a picture of poaching with poisonous plants in Campania. An examination of the decrees issued in Southern Italy against this illegal activity over the centuries was also carried out. The main sources consulted were Savelli (1681), Dentice (1853), Dorotea (1863) and the *Gazzetta Ufficiale del Regno* after the unification of Italy in 1861. In this report we have devoted special attention on the fundamental contribution to the knowledge of this practice, due to Achille Costa, zoologist and director of the Museum of Zoology of the University of Naples from 1860 to 1880, who wrote *Delle chiusarane e della pesca colla melaterragna e col totumaglio nel Golfo di Napoli* (1870), subsequently summarized in the Italian *Annali del Ministero di Agricoltura, Industria e Commercio*, curated by A. Targioni Tozzetti (1871).

Results and Discussion

There was various evidence of poaching with poisonous plants in Campania from XVI to XIX century according to the decrees issued on this topic within the Kingdom of Naples. On 16th of April, 1543 the Regia Camera della Sommaria (an administrative, jurisdictional and consultative Institution operating during the Angevin and Aragonese regimes in the Kingdom of Naples) forbade the throwing of yew or other poisonous herb into the rivers by which fish die ("è proibito di gettare il tasso o altra erba venefica ne' fiumi per cui muoiono i pesci" – De Vincentiis, 1878). The *Prammatica XIX De nautis et portubus*, was a law ratified on 1784 that regulated in the Kingdom of Naples the entire spectrum of activities related to sea and freshwater, included fishing, subsequently reinforced by the decree enacted by Ferdinando II King of Naples on 1834, which explicitly referred to fishing with poisonous plants: "for fishing with *pomo terragno*, titimol, vomitic nut, yew or other substance that makes the fish's food harmful, the first degree of imprisonment will be applied for the mere fact of having made use of these substances, in addition to the fine of 3 to 12 ducats" ("Per la pesca col pomo terragno, col titimolo, colla noce vomica, col tasso o con altra sostanza che renda nocivo il cibo de' pesci, si applicherà pel solo fatto di essersi valuto di tali sostanze, oltre l'ammenda di 3 a 12 ducati, il primo grado di prigionia" – Suppl. Cod., 1850). But even after the establishment of the Kingdom of Italy (1861) the practice of using poisonous plants in fishing was still alive, becoming the target of laws aiming to ban it in all Italian regions (Gazzetta Ufficiale, 1883).

Chiusarane was a fishing system based on aggregating nets, and the use of poisonous plants to stun fish, traditionally practiced by the Neapolitan fishermen of Santa Lucia, the Lucians, who possessed the necessary capital to organize such a fishing system on the islands of Capri and Procida (Sirago, 2009), causing protests among fishermen on those islands who were strongly opposed to this fishing technique (Armiero, 1998). The term *chiusarane* was already known in the time of Giambattista Basile (1583-1632) who used it in a fairy tale of *Lo Cunto de li cunti*: "And so, after sending a hundred fishermen out to sea, they set up many skewers, chiusarane (space enclosed by nets where fish can enter but not leave), palangrese (fishing tools consisting of a long hemp rope to which thinner strings are attached, each ending in a hook.), buoli (drift net also called bolentino or ledger rig), pots, lines and wires" ("E cossí, mannato ciento pescature a maro, apararo tante spedune, chiusarane, parangrase, buole, nasse, lenza e felacciune" – Basile, 2013, Cunto I, 9).

Recent ethnobotany research indicates that some of the plants included in XVIII century Prammatica regulating fishing in Southern Italy, as *titimallo* and *pomo terragno* were still used by Italian fishermen till the last century, whereas neither *noce vomica* or *tasso* were reported in the studies carried out during the XIX century. *Strychnos nux-vomica*, native to tropical and sub-tropical Asian and Australian (Agarwal & Gupta, 2023) is a renowned medicinal plant, used in oriental medicine for curing different diseases, ranging from pains, acute inflammatory issues, headaches (Behera, 2019). Nux vomica (*noce vomica* in Italian) is a drug consisting of the dried, ripe seeds of this plant and was known in Europe in the XVI century. It was reported as a new drug in the epistolary between Calzolari and Aldrovandi (Pugliano, 2017) and was already sold in England in the middle XVII century and in Germany in the late XVII century, mainly for poisoning animals (Evans, 2009; Ujváry, 2010). Already known as a potent poison in the Dioscorides *Materia Medica*, *Taxus baccata* (European yew) is a relict tree species, today reduced in the Mediterranean region to small populations (Linares, 2013). All the parts of the tree, except the arilli, are toxic and animal poisoning due to ingestion of part of the tree, prevalently leaves, was extensively reported (Poudel et al., 2021). The mention of yew both in the 1543 decree of *Regia Camera della Sommaria* and in that by 1835 it became widely known, points to a persistent use of *T. baccata* as an ichtyotoxin in illegal fishing, at least in the Kingdom of Naples. This represents novel information, to the best of our knowledge, and no recent ethnobotanical reference about this use of yew has been reported in Italy.

The name *titimollo* or *titumallo* refers to *Euphorbia lathyris* (Penzig, 1974). As far as concerns Southern Italy, different *Euphorbia* species have been employed as a fish poison. The latex of *E. dendroides* was used for ichthyotoxic activity in Basilicata and Calabria (Guarrera & Leporatti, 2007), in Aegadian islands (La Rosa et al., 2021) and in Pantelleria island, where also *E. segetalis* is recognized as a fish poison (Quave & Saitta, 2016). In Sicily, the latex from *E. characias* and *E. rigida* has been used to 'poison' the river in order to flush out eels, making them easier to catch (Leto et al., 2013; Savo et al., 2013).

Pomo terragno deserves a more detailed account. According to Pliny, the plant called *malum terrae* by the Latins was actually a species of *Aristolochia*, a genus that includes several species used in traditional medicine in the Americas, Asia and Europe, despite the reported renal toxicity (Heinrich et al., 2009). Birthwort (*Aristolochia* spp.) was frequently included in Greek and Roman recipes for treating a variety of ailments, from gout to bladder stones and kidney disorders, and was also highly recommended against snake bites (Scarborough, 2011). The *Aristolochia* called *venenum terrae* by the fishermen of

Campania, had a rounded root and could possibly be identified as *A. rotunda*. Pliny mentions that he was present when "they pounded it with lime and threw it into the sea; immediately the fish flew towards it with surprising greed, and being struck dead in an instant, they floated to the surface" ("contusam mixta calce in mare sparsere. Advolant pisces cupiditate mira statimque exanimati fluitant" – Pliny, 1983, NH XXV, 54).

Pliny elsewhere reports that a variety of cyclamen called *chamaecissos*, which has a single leaf and a branched root, was also used for fishing (Pliny, 1983, NH XXV, 67–69). For Pliny, therefore, *Aristolochia* and cyclamen had the same uses, and the reputation of members of the latter genus as ichthyotoxic is also found in Dioscorides, who named cyclamen as ἰχθῦοθήρα (ἰχθῦς = fish + θήρα = hunting – https://stephanus.tlg.uci.edu/lsj/#eid=52959 – Dioscorides, 1958, 2, 164), from which we can deduce that even the Greeks used this plant to catch fish. Apparently, the two genera (*Aristolochia* and *Cyclamen*) have overlapped in popular usage over time, and the name *Aristolochia* with a round root has also been used to identify cyclamen species, as *C. europaeum* (Stirling, 1995–1998).

In the second half of XIX Century, about two thousand years after Pliny, another naturalist described in detail the use of species belonging to the genus *Cyclamen* by Campanian fishermen. Trying to harmonize the existing legislation in the ancient pre-unitary Kingdom of Naples and legislation of the Kingdom of Italy, old decrees and laws were subjected to a scrutiny. Concerning fishing, Achille Costa, chair of Zoology at the University of Naples, and director of the Museum of Zoology, was asked to ascertain if the use in fisheries of ichthyotoxic plants, and in particular of the so called *mela terragna*, had to be banned, according to the previous legislation. A few decades before Tenore and Pasquale, describing the species of *Cyclamen* found in the Kingdom of Naples, reported that all *Cyclamen* species were used by the local fishermen to poison fish: "to do this they pound the said tubers, place them in a closed bag, and this they infuse into the water; after a short time the fish are dead afloat" ("a far questo essi pestano i detti tuberi, li ripongono in un sacco chiuso, e questo infondono nell'acqua; dopo breve tempo i pesci vengono morti a galla." – Tenore & Pasquale, 1847).

Achille Costa (1870) identified the phytonym *mela terragna* with *Cyclamen neapolitanum*. Presently, *C. neapolitanum* and *C. poli* are considered as synonyms of *C. hederifolium* (https://www.gbif.org/species/4008204; www.gbif.org/species/4008056). As a result of molecular studies, the genus *Cyclamen* has recently been placed in the family Myrsinaceae, which includes trees or shrubs of tropical floras (Pignatti, 2018).

Costa had the chance of observing fishermen in action with the plant. The preparations of *mela terragna* tubers followed these steps: 1. Tubers were cut into small pieces; 2. The pieces were grated, producing a juicy paste; 3. The paste was transferred to small bags of coarse cloth, suspended from the end of a long pole. Then, fishermen pushed the pole into seawater and rubbed the bag between the rocks of the seabed, causing the release of the juice from *C. neapolitanum* tuber paste. Notably Costa stressed that the purpose of fishermen in using land-apple was to snare fish from places in which nets could not be used. But let now consider how fish reacted to the contact with the juice of the plant. "As the *mela-terragna* paste begins to be rubbed between the reefs the fish that was hiding among them moves away taking the opposite direction to them" ("Come comincia a fregarsi la pasta di *mela-terragna* tra gli scogli il pesce che tra essi annidavasi si allontana prendendo direzione opposta a' medesimi" – Costa, 1870). Then, fish escaping from *mela terragna* juice can be captured by the circular belt of vertical nets prepared by fishermen.

Starting from these preliminary notes, Costa planned a series of field observations: "only in this way one can study what naturally occurs in such cases. The experiments that are made in the laboratory by changing many of the conditions, do not have for us the same importance for application to fishing" ("poiché in tal modo soltanto può studiarsi ciò che naturalmente avviene in tali casi. Gli esperimenti che si fanno nel gabinetto mutando molte delle condizioni, non hanno per noi la stessa importanza per l'applicazione alla pesca" – Costa, 1870). The results contradicted what was generally reported by fishermen, in particular: 1. Fish returned after only three days to the place where *mela terragna* juice was released into seawater, and not after two weeks, and 2. Fish could be eaten and did not acquire any unpleasant taste.

Costa, afterwards hypothesized that only temporary effects could be attributed to *mela terragna*, and in the lab confirmed his field observations after carrying out histo-anatomical observations. The main effects observed were blood congestion, mainly of the gills, and an acceleration of respiratory rates, whereas no relevant alteration of abdominal organs was found (Costa, 1870), leading to the conclusion that the action of *C. europaeum* on fish was prominently irritant and short lasting. Finally, fish caught in this way, if placed immediately in containers with pure seawater, remained alive only a little less than the one caught alive without the use of the *mela terragna*. These observations led Costa (1870) to declare that the plant should not be considered as capable of producing poisoning, and that fishing with *C. europaeum* and allied species could, and indeed, should, be permitted rather than prohibited, since it did not result in any long-term toxic effects.

In the same year Adolfo Targioni Tozzetti was appointed chairman of the Advisory Commission for Fisheries, by the Italian Ministry of Agriculture, Industry and Commerce, making several trips to Italy to study fish fauna and the related economic network. In recounting his survey, published in the *Annali del Ministero di Agricoltura, Industria e Commercio*, Targioni Tozzetti (1871) reported Achille Costa's opinion on the subject that confirmed his positive opinion about *chiusarane*, using *Cyclamen europaeum*, or *Euphorbia lathyris* (*tutumaglia*). Interestingly, in another document reported in Targioni Tozzetti (1871), that was edited by the *Società per l'allevamento dei pesci e per la pesca razionale nel golfo di Napoli*, there is a mention to *chiusarane*: "*Chiusurane* fishing, for which the fuligin and juice of acrid and poisonous plants, such as *Menispermum cocculus*, the euphorbiaceae, nux vomica, etc., are used, is equally, harmful" ("La pesca delle *Chiusurane*, per cui adoperansi la fuligine ed il succo di piante acri e velenose, come il *Menispermum cocculus*, l'euforbiacee, la noce vomica ecc. è altrettanto, dannevole"). Hence, another plant is referred to, *Menispermum cocculus*, not reported in other documents of that time, nor previously listed, to the best of our knowledge. *Anamirta cocculus* (syn. *Menispermum cocculus*) is a species belonging to the Tribe Coscinieae, Family Menispermaceae, found from India to West New Guinea in lowland and coastal forests, near riverbanks, but also in savannah hilly countries (Forman, 1978). The fruits have been imported in Europe via Alexandria and Middle East since the XVI Century (Flückiger & Hanbury, 1879) and were used to eliminate lice from human skin, but in England were also mixed to breadcrumbs and honey and used as a bite to stun fish (Forman, 1978). Their biological activity is due to the presence of picrotoxanes, a mixture of two alkaloids, picrotoxinin and picrotin that can cause nausea, muscle contractions, augmented respiratory rates, convulsions, also leading to death (Shi et al., 2022).

Notwithstanding the positive opinion of Achille Costa (1870) about fishing with *chiusarane*, this practice was never approved.

Some years later (1883), in the *Gazzetta Ufficiale del Regno d'Italia*, march, 14, n° 61 was published the decree n. 1223 (serie 3a) that enshrined the final prohibition for the use of toxic plants in fishing: "Art. 6. It is forbidden to use for fishing narcotic, suffocating, corrosive and poisonous materials, such as nux vomica, morphine, lime, phosphorus, black smoke or soot, and so on, or explosive materials, such as dynamite, gunpowder, etc. It is also forbidden to collect or sell fish taken by such means" ("È vietato di adoperare per la pesca materie stupefacenti, soffocanti, corrosive e velenose, come ad esempio la noce vomica, la morfina, la calce, il fosforo, il nero di fumo o fuliggine e via dicendo, oppure materie esplodenti, come la dinamite, la polvere pirica, ecc. È pure vietato di raccogliere o vendere i pesci presi con tali mezzi"). In the following years the use of *chiusarane* in the bay of Naples was permanently abandoned.

Author contributions

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Formal Analysis: O.S., L.T., A.P.
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Dissemination and communication of astronomy in Naples: from the Enlightenment to social media

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Abstract

The dissemination of scientific knowledge is a usual practice for Neapolitan astronomers, having roots in the times when Naples did not yet have an Observatory. That tradition continues today to animate the initiative of the Capodimonte Observatory in disseminating astronomical culture to an ever wider audience of curious and passionate about the science of the cosmos. Among the many scientists who in Naples have deeply contributed to making astronomical knowledge accessible to all, Ernesto Capocci was undoubtedly the main protagonist of literary initiatives, including a science fiction novel, valid for the education and dissemination of astronomy. This article examines the role of Neapolitan astronomers in the educational outreach campaign of astronomical knowledge and the different modes of communication they used, from the Enlightenment to the contemporary age, to spread science in society.

Keywords: Popular Astronomy - Astronomical Outreach - Italian Astronomers.

Riassunto

La diffusione della cultura astronomica è per gli scienziati partenopei una tradizione che affonda le sue radici nei tempi in cui Napoli non aveva ancora una specola. Quella consuetudine continua ancor oggi ad animare l'iniziativa dei ricercatori dell'Osservatorio di Capodimonte per la divulgazione delle conoscenze scientifiche verso platee sempre più ampie di curiosi e appassionati della scienza delle stelle.
Tra i tanti scienziati che a Napoli hanno contribuito a rendere la conoscenza astronomica accessibile a tutti, Ernesto Capocci è stato

senza dubbio il principale protagonista di iniziative editoriali, tra cui un romanzo di fantascienza, per la divulgazione scientifica.
Questo articolo ripercorre, dall'Illuminismo all'età contemporanea, il ruolo degli astronomi napoletani e le diverse modalità di comunicazione utilizzate per diffondere le conoscenze scientifiche nella società.

Parole chiave: Comunicazione Scientifica, Divulgazione Astronomica, Astronomi Italiani

Introduction: The circulation of the sciences in Enlightenment Italy

In 1878 the Senate of the Kingdom of Italy discussed a law to allocate funds to purchase a new telescope for the Martian research of Giovanni Virginio Schiaparelli (1835-1910) at the Brera Observatory. During this discussion, the Neapolitan astronomer and senator Annibale de Gasparis (1819-1892) cited the witty answer that François Arago (1786-1853) gave to a lady asking him what astronomy was for: "Madam, astronomy can help bring down the price of sugar" (Senato 1878, p. 657). De Gasparis thus wanted to demonstrate how scientific research can directly benefit civil society, and astronomical knowledge needs to be shared with those who are not scientists using rigorous and impactful communication methods. Francesco De Sanctis (1817-1883), minister of Public Education, praised the astronomer of Capodimonte for giving a speech so high that it seemed to hear the music of the stars of which Pythagoras had spoken and for turning the discussion on a proposed legislation into a scientific party (Taddei 1878).
The dissemination of scientific knowledge, especially astronomical knowledge, has been a goal that astronomers have always faced with great attention and passion. Galilei's works had a broader intent than addressing only contemporary scientists and philosophers. Having chosen a literal form in a dialogic type and the Italian language instead of Latin, his books were also accessible to a large audience of non-specialists. They represented a way to communicate new concepts and astronomical discoveries to a broader audience; today it would be called education and information for the public. The encyclopedic vision of knowledge, typical of the Age of Enlightenment, prompted an acceleration in the communication of science, also broadening the audience to which it could be addressed. An example among many is the *Lettres a une princesse d'Allemagne sur divers sujets de Physique e de Philosophie* published between 1760 and 1762 by Euler.
In the eighteenth century, the debate on the living forces between Cartesians, Leibnitzians, and Newtonians animated the Italian scientific and cultural interest, finding in the Alma Mater and the Institute of Sciences and Arts of Bologna a center for comparison and paradigmatic reference (Cavazza 2013). Central was the role of Francesco Algarotti (1712-1764) in spreading Newton's new concepts of physics and optics even to an amateur audience. In 1737 he published in Naples *Il Newtonianismo per le dame*, a dialogue with a young marquise on physics, optics, and astronomy by the English scientist[1]. Algarotti dedicated his book to Bernard le Bovier de Fontenelle (1657-1757), the intellectual who brought science out from solitary laboratories and libraries of the erudite to introduce it in the circles and the salons for ladies. In the dedication, he emphasized that if "The temple shrine will always be addressed to the ministers and devotees of the deity", the scientific knowledge was to be disseminated

[1] Newtonianism for ladies, a series of lively dialogues on optics, was a milestone in the popularisation of Newtonian philosophy. For a broader understanding of Algarotti's work, his aims, and his experimental methodologies for the cultural promotion of Newtonianism (Mazzotti 2004).

to wider audiences: "The vestibule and other parts of the temple will still be open for the layman" (Algarotti 1737). The work had great success both in Italy and abroad. However, two years later, the book was included in the Index of books prohibited for moral indecency. In 1752 Francesco Maria Zanotti (1692-1777), a convinced Cartesian and pupil of Algarotti, published *Della forza de' corpi che chiamano viva*, a dialogue held in Naples with the main Neapolitan protagonists engaged in experimental sciences and age-old debate, such as Francesco Serao, Niccolò di Martino, Felice Sabatelli and Faustina Pignatelli[2]. The volume effectively testifies to both the different positions and the perimeter within which eighteenth-century science moved, no longer reserved exclusively for theologians and academics. The works tried to voice different experiences and sensitivities, involving men and women from various social and cultural backgrounds and sensitizing a broader interest in new physical knowledge, especially experimental (Schettino 1998).

In Naples, the scientific circle, formed around the collections of Ferdinando Vincenzo Spinelli (1691-1753), Prince of Tarsia, was animated by many Neapolitan scientists interested in conducting experiments on electrical phenomena and making astronomical observations. In Naples, there was no equal attention to the scientific commitment and participation in the debate on "vis viva" for the dissemination of knowledge of experimental physics and astronomy, except for the scientific-encyclopedic volume *Scienza della natura*, published in two volumes between 1774 and 1778 by Giovanni Maria della Torre (1712-1782). The only astronomical information for public use, printed in Naples, was the brief information and ephemeris reported from 1758 in the *Calendario della Corte*, which continued the publication of the *Discorso istorico* printed by some Neapolitan printers starting from 1721. It also contained *L'Almanacco Universale del Commentatore d'Urania, o sia del Segretario delle Zifre Celesti* (Zappella 2001, p.705). The oldest issues of the publication, those of 1721 and 1723, are kept in the library of Società Napoletana di Storia Patria. The volume of 1721 is printed in Milan and Naples and dedicated to Giuseppe Brunassi (1670-1740), Elected of the People[3] and Duke of San Filippo. It was published in Naples in 1723 by the printer Francesco Ricciardo and dedicated to the Marquis Ferdinando Emanuele Alvarez, regent of the Collateral Council.

The Neapolitan Observatory and astronomy for everyone

With the return to Naples of Giuseppe Cassella (1755-1808), scholar of Sabatelli, the volume *Dei principali movimenti e fenomeni de' corpi celesti* was published in 1788. It was the first Neapolitan publication with ephemeris calculated for the meridian of the city, containing scientific information and astronomical data helpful to astronomers and sailors. Cassella also wanted to make this publication "for the advantage of the public and for those who care about the progress of astronomical sciences" (Cassella 1788, pp. V-VI). After the years spent in Padua

[2] Francesco Serao (1702-1783), a Neapolitan scientist and philosopher, was a professor of anatomy and medicine at the University of Naples. He followed the thinking of Descartes. Niccolò di Martino (1701-1769) was a professor of Mathematics at Naples University. He was considered the undisputed leader of the Neapolitan Newtonians. Felice Sabatelli (1710-1786) was a professor of Astronomy at the University and the Navy Academy of Naples. Faustina Pignatelli (1705-1785), princess of Colubrano, was a Neapolitan noblewoman much appreciated by Voltaire and Lalande and had a close correspondence with Zanotti. She participated in the debate that divided the novatores Newtonians from the Cartesians with acute and original reflections of an epistemological nature. She was the second woman admitted to the Institute of Sciences and Arts of Bologna after Laura Bassi (Bottone 2019).

[3] The Elected of the People was a representative expressed by the Neapolitan districts ("Sedili") who participated in the city's municipal government (Tutini 1644).

learning the use of astronomical instruments with Giuseppe Toaldo (1719-1797), founder and first director of the Observatory of Padua, Cassella returned to Naples as a royal astronomer and professor of nautical astronomy at the Academy of Navy and mechanics at the Royal College of Artillery. In 1791, he obtained permission from Ferdinand IV, king of Naples, to realize the Neapolitan observatory at "the building of the disused Royal Studies, intended by His Majesty as the General Museum and Academy of Arts and Sciences" (Gargano et al. 2012, p. 17). The architect Pompeo Schiantarelli (1746-1805) realized the astronomical tower and sundial project. Due to static problems, the Observatory was not built. However, the astronomical calendars redacted by Cassella had a wide echo and diffusion, also obtaining a flattering judgment from the Academy of Sciences, Letters, and Arts of Padua. In 1799 the *Calendario repubblicano per l'anno I della Repubblica Napolitana*, drawn up by Cassella, also introduced the civil and political innovations, including the new constitutions, that the new regime wanted to achieve.

For the support given to the Republica Napoletana in 1799, the professor of astronomy and nautical sciences at the University of Naples, Ferdinando Messia de Prado (1757-1810), was exiled to France. However, with the arrival on the throne of Naples of Giuseppe Bonaparte in 1806, he was first reinstated to the chair and, in 1809, appointed as director of the Astronomical Observatory of Naples, decreed by Bonaparte on 27 January 1807 at the ancient monastery of Naples San Gaudioso in Caponapoli (Capaccioli et al. 2009). In the *Calendario dell'anno 1810 pel Regno di Napoli fatto nell'Osservatorio di S. Gaudioso*, Messia de Prado indicated that the ephemeris had a scientific and civil use peremptorily: "In this calendar, there will be neither predictions nor omens. It is now time to stop deceiving the people with the names of that vain doctrine, which is called Astrology" (Messia de Prado 1809, p. 3). The text marked a further step for Neapolitan scientists to educate in the sciences of the sky and bring more people closer to the knowledge of astronomy. In 1811, Federigo Zuccari (1783-1817), a pupil of Barnaba Oriani (1752-1832) in Brera, was called to the direction of the Observatory by Joachim Murat, king of Naples from 1808, who wanted to give the oldest Neapolitan scientific institution a new and magnificent building on the Miradois hill, not far from the royal palace of Capodimonte. The splendor of the building and the rich and modern collection of astronomical instrumentation also attracted the attention of the nascent Neapolitan periodical press. Thus, the editor of the magazine *Giornale degli annunzj*, founded in 1813, invited Zuccari to give scientific explanations for unusual and ordinary astronomical phenomena seen in the sky. "What is believed to be a new star is none other than Mars" - Zuccari argued - "The people considered it a new guest of the Royal Palace of Urania. When the knowledge to recognize the identity of the same object is lacking, the imagination multiplies it and makes two or more according to appearances" (Zuccari 1813).

In addition to the articles in the Neapolitan newspapers, Zuccari modified the Calendar's structure by introducing a series of "Discorsi", astronomical essays, also of a popular nature, to train and educate a public increasingly interested in astronomical issues. In the five essays he published before his untimely death, Zuccari dealt with the main celestial phenomena, the rotation of the Earth, stellar positions, the measurement of time, and astronomical instruments.

The first astronomical observation, made on the night of 17 December 1819, marked the conclusion of the construction works of the new Observatory. The astronomer Carlo Brioschi (1781-1833) observed the star Alpha Cassiopeiae with a repeating circle of Reichenbach from the eastern dome. The

Fig. 1: Portrait of an Official of the Nunziatella. In the background a terrestrial globe, some books, a geographical map, and a compass. Oil painting on canvas, first half of 19th century, Neapolitan school. Credits: Charterhouse and Museum of San Martino.

king of Naples, Ferdinand I (1751-1825), and the Crown Prince, Francesco di Borbone (1777-1830), were among the first persons to visit the new monumental building. They arrived on Miradois Hill "to see the completed observatory" (Ferdinando I di Borbone 1821) on 28 July and 10 August 1821, respectively. The Observatory became a reference point for astronomical studies and a cultural stronghold for its neoclassical architecture, its panorama, dominating the city and the Gulf of Naples, and the instrumental collection of the highest order in Europe. Intrigued by the beauty of space, Italian and foreign travelers frequently asked Brioschi to visit the Observatory during their stay in Naples and observe the sky with the powerful Capodimonte telescopes. Moreover, some Neapolitan professors, such as those of mathematics from the military academy of Nunziatella, annually took students on educational visits to the Observatory (Fig. 1) (Amante 1831). Already in 1820, the Minister of the Interior, Giuseppe Zurlo (1757-1828), urged Brioschi to define a calendar of biweekly openings of the Observatory for "young people eager to learn astronomy" (Zurlo 1820).

The Cultural Astronomy of Ernesto Capocci

The main Neapolitan protagonist of scientific dissemination activities was Ernesto Capocci (1798-1864). He was a prominent figure in the Neapolitan cultural, political, and scientific life of the first half of the nineteenth century. He was an accurate and open-minded scholar. He looked carefully at the European experiences of the time, combining "the love of beautiful literature... with the worship of science" (Zanella 1880, p. 134). Capocci made a series of editorial initiatives to educate and disseminate scientific knowledge. A precursor of science fiction novels, the astronomer of Capodimonte, was also among the first scientists to translate the astronomical notions of the Divine Comedy into a popular text, explaining Dante Alighieri's profound cosmographic knowledge in a simple and accessible way to all.

Capocci was Zuccari's nephew. As early as 1815, he began to attend the Naples Observatory dealing with meteorological surveys and then observing and studying comets. In 1825 he published his first volume of scientific popularization: *Dialoghi sulle comete scritti in occasione delle cinque apparse nell'anno 1825* (Dialogues on comets written in occasion of the five comets appeared in the year 1825). Presenting the work to the Council for Public Education on 8 December 1825, the typographer Nicola Pitrelli and the royal reviewer Girolamo Pirozzi wrote that Capocci has strived "to raise our minds to greatness with a beautiful method and pleasant expressions" (Capocci 1825, p.88). Under the pseudonym of Noreste, an

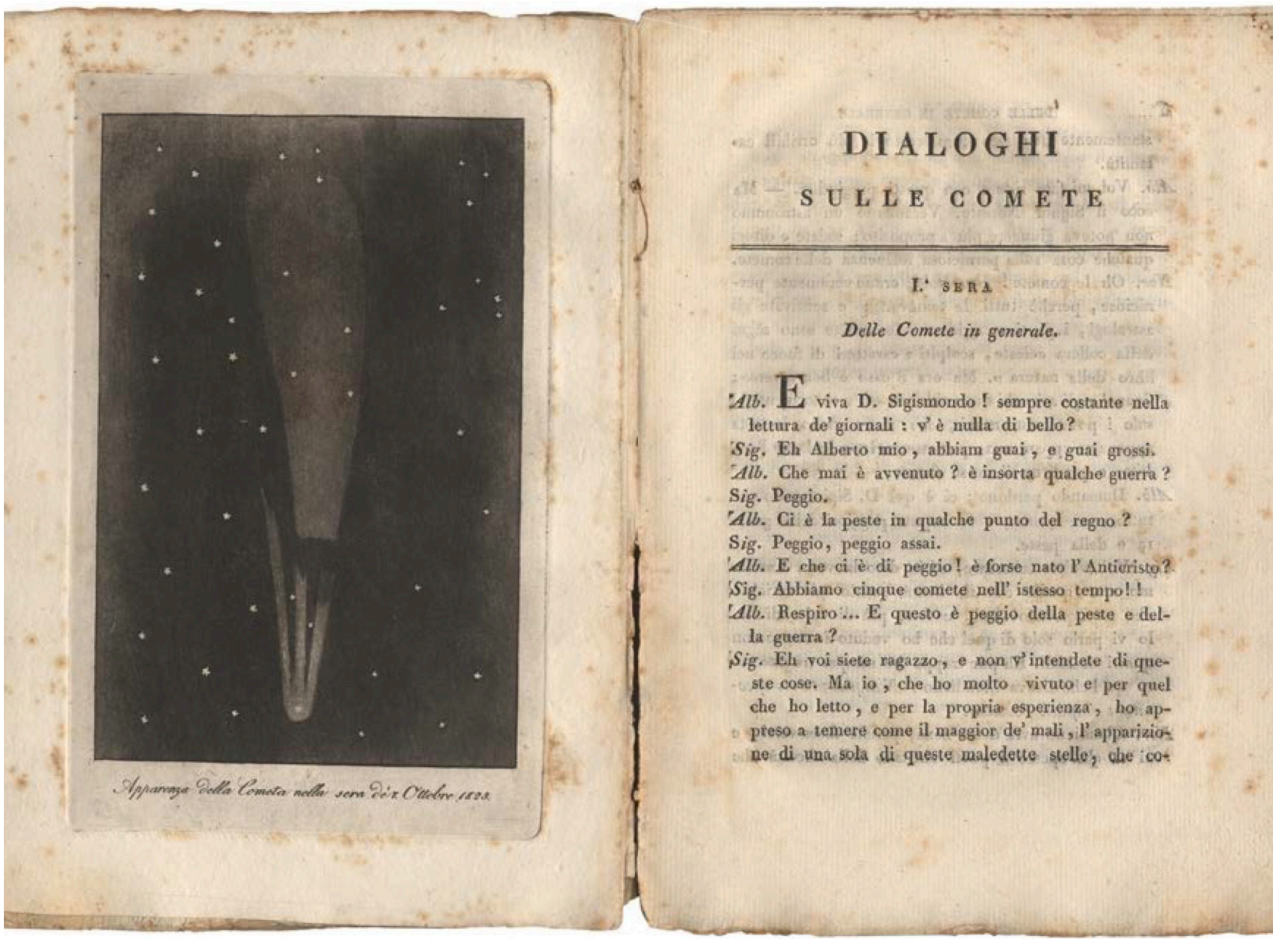

Fig. 2: Engraving of comet C/1825 N1 from *Dialoghi sulle comete* by Capocci (Naples, 1825). Capocci began to observe it from the Capodimonte Observatory on the night of 25 August, calculating its orbital parameters some days later (Notizie 1825). The comet was intrinsically very bright, reaching magnitude 2-3, and had an exceptionally long period of visibility to the naked eye. In Capocci's observation of 7 October, the comet's tail appeared "divided into three branches: the two lateral ones were unequal in length, and so encircled the nucleus, which seemed to form a parabola, in whose focus was the nucleus. The third branch, the main one, stood out in the middle of the other two with more intense light... After a few days, these branches merged into one" (Capocci 1825, pp. 30-31). Giacomo Leopardi also observed this comet as a letter to his brother testifies. Credits: Private collection of Maurizio Capocci, the descendant of the astronomer.

anagram of his name, Capocci took as a pretext the discussion that arose in a coffeehouse on the five comets[4] seen in Naples to explain to two gentlemen those celestial phenomena and the scientific knowledge of the time on the comets, simple and effective way (Fig. 2). Capocci wrote in the preface of Dialoghi: "The many chatters that I had to hear in this regard... the desire to break down prejudices, unfortunately still common, and to spread the taste for astronomical things, unfortunately still a pilgrim, led me to publish them... They are adapted to the ordinary intellect to make them acceptable... on the other hand, they contain everything a scholar could wish to know about comets" (Capocci 1825, p.1).

[4] The five comets that appeared in 1825 are c/1825 K1, C/1825 N1, C/1825 P1, 2P/Encke, and C71825 V1. The comet c/1825 K1 was discovered by Jean Félix Gambart (1800-1836) on 19 May at the Marseilles Observatory in the Cassiopeiae Constellation. C/1825 N1 was discovered by Jean Louis Pons (1761-1831) on 15 July from a Lucca bell tower in the Tauri Constellation. C/1825 P1 was discovered by Pons on 9 August from Florence in the Aurigae Constellation. 2P/Encke, named Encke comet or the comet of the ready return, was predicted by Johann Franz Encke (1791-1865) and observed by Benjamin Valz (1787-1867) in Nimes on 13 July in the Tauri constellation. C71825 V1 was discovered by Pons in Florence on 7 November in the Eridani Constellation (Kronk 2003, pp. 69-80).

In dialogue with Alberto and Sisgimondo, Noreste explained the general advantages of astronomical studies in other fields such as physics, meteorology, mechanics, navigation, and geography. The scientist argued that "astronomy saves the ignorant from the fears inspired by the sight of an eclipse or a comet". Therefore, "astronomy must be highly esteemed in a civilized kingdom, and an observatory is of the utmost importance". To Alberto's objection, who argued that the knowledge achieved by astronomy is sufficient for the needs of society, and "the observatory is rather a luxury thing ... and not at all necessary", Noreste replied that "people can do without everything, even macaroni!". Finally, the astronomer stresses that "if astronomers wanted to think about their own business, they should reconcile themselves with Astrology and credit it with the common people, making every effort to extend the empire of this arcane science" (Capocci 1825, pp. 48-50). Capocci seemed to want to resume Messia de Prado's introduction to the Calendar of 1810.

After having experimented with the way of the historical novel, by publishing in 1839 *Il primo viceré di Napoli* in which Capocci narrated the chivalrous events of the challenge of Barletta, the Capodimonte astronomer conceived in 1845 *Annuario del reale Osservatorio di Napoli* (Almanac of the Royal Observatory of Naples), a publication intended to broaden the spectrum of scientific information also to sciences related to astronomy. In Capocci's intentions, the volume of an encyclopedic type was "destined to go to everyone's hands... both for the improvement of the mind... and practical uses" (Capocci 1845, p. 3). The astronomer proposed wide dissemination of astronomical, meteorological, geographical, and statistical knowledge, making them simple and accessible. The publication, however, was short-lived, printed for only two years. During the decade in which he ruled out the scientific activities of the Observatory for the support given to the liberal uprisings of the Risorgimento, Capocci devoted himself with greater intensity to literary studies and initiatives for the dissemination of astronomy and scientific culture (Capaccoli et al. 2009). In 1853 he published *Quadro del Sistema planetario solare* (Plate of the solar planetary System), a graphic plate with the physical parameters of planets, comets, and asteroids "for the education of youth and to aid memory". The panel enjoyed great appreciation, including that of Angelo Secchi (1818-1878), director of the Observatory of the Roman College, and a good sales success, so much so that the publisher asked Capocci to write a user manual for explaining the scientific contents of the "lithographed sheet with great skill" (Capocci 1853, pp. 1-2). He published a broad erudition work three years later, *Illustrazioni cosmografiche della Divina Commedia* (Cosmographic description of the Divine Comedy), a volume of notable cultural impact on literature and the popularization of science. It brings out simply Dante Alighieri's profound astronomical knowledge, which emerges in a long sequence of triplets distributed in the three Cantiche. Distinguished and well-known scholars and scientists dedicated academic essays to the study of the astronomical elements present in the poem of Dante, including the date of the journey to the Christian afterlife. Pisa's young and promising mathematician, Galileo Galilei (1564-1642), stands out among many scholars. In 1587 he held two conferences at the Florentine Academy *Around the figure, place, and dimension of the hell of Dante*. With scientific accuracy and poetic grace, in crossing the three otherworldly realms, Capocci set himself a different goal: to make all the astronomical references described by Dante popular and recognizable by anyone, even "by those who are not profound analysts". Aware of the excellent task and the work: "it is not an undertaking to be taken lightly", Capocci structured his celestial journey in a dialogical form accompanied by Beatrice, an

attentive reader of Dante, who confided to the astronomical guide that "she had never been able to understand what those lines of the poem that speak of astronomy mean. I am amazed" - Beatrice argues - "how no Italian astronomer has ever thought of studying specifically and clarifying the true meaning of such enigmatic passages of the Poem" (Capocci 1856a, p. 1; Olostro & Gargano, 2015).

A year passed, and Capocci began a new literary adventure. Anticipating the publication of Jules Verne's novel *De la Terre à la Lune* eight years later, Capocci became the forerunner of the literary vein of science fiction. In fact, he published in 1857 *Relazione del primo viaggio alla Luna fatto da una donna l'anno di grazia 2057* (Report of the first journey to the Moon made by a woman in the year of grace 2057). It is a refined story by the Neapolitan scientist conceived through the report of the astronaut Urania (Olostro & Virgilio 2001). Accompanied by the astronomer Arturo and the crew of the balloon Giordano Bruno, she wrote, just "happily arrived and settled in this delightful part of our small earth system!" (Capocci 1857, p. 1), about his journey to his terrestrial friend: Ernestina. Capocci's pamphlet, in its essentiality of 22 pages in 16°, is inherent as a work in which the scientist's astronomical knowledge and the extraordinary ability to predict modalities and needs emerged. Only astronomy and engineering that emerged in the twentieth century had to and knew how to face. The Journey to the Moon by Capocci attracted the attention of mid-nineteenth-century readers to the unprecedented challenges offered by the new astronomy and new industrial technologies. At the same time, the story intrigued and interested the public for research and studies on the Solar system in which the astronomer Annibale de Gasparis was one of the main protagonists of the time. The long series of planetary discoveries made by the Capodimonte Observatory allowed de Gasparis to make the sky of Naples "the favorite garden of asteroids" (Gargano 2023, p. 3).

To his intense literary production, Ernesto Capocci added a fruitful collaboration with Neapolitan newspapers and magazines, such as *Il Nomade*, *Lucifero*, and *Poliorama Pittoresco*, to name just a few. Like his uncle Zuccari, Capocci took up every hint given by discoveries or surprising celestial phenomena to divulge astronomical knowledge. He wrote about the formation of the asteroid belt between Mars and Jupiter, comets, the phases of the Moon, and eclipses. In particular, Capocci published in 1856 the article: "Il più grande cannocchiale del mondo" (The biggest telescope in the world) in the magazine *Il Nomade*. He dwells on the technical innovations that make it possible to obtain increasingly powerful scientific instruments, like the 182 cm Leviathan telescope constructed in 1840 by Lord Rosse, William Parsons (1800-1867) at Birr in Ireland, and on the need to combine economic, public and private, and scientific efforts. Then Capocci proposes the construction of an international "Cosmic Observatory" in the Peruvian Andes to carry out new research and discoveries "inside the nebulae or in the valleys of the Moon, or the holes of the solar photosphere" (Capocci 1856b, 1856c). This idea took shape a hundred years later, when the astronomers Walter Baade (1893-1960) and Jan Oort (1900-1992) thought, in the spring of 1953, to establish a large observatory shared between their two countries. The following year, astronomers from six European countries signed a declaration to establish a European observatory in the southern hemisphere, in the Chilean Andes. This scientific decision was followed by the ESO agreement signed by Belgium, Germany, France, the Netherlands, and Sweden on 5 October 1962. Italy's entry into ESO took place only on 24 May 1982, due to the decisive role played by Franco Pacini (1939-2012), a Florentine astronomer who had led ESO's scientific division since 1975. Thus, 126 years after Ernesto Capocci launched the farsighted idea, Italy officially became a member of the most important international organization in the astronomical

field (Blaauw 1991).
On the death of Capocci in 1864, Annibale de Gasparis was appointed director of the Capodimonte Observatory. He was a famous astronomer throughout Europe for discovering nine asteroids; the last discovery was Beatrix in 1865, the asteroid dedicated to Dante Alighieri. De Gasparis made every effort to upgrade the Institute and gave new impetus to meteorological and geomagnetic measurements. Although he was a pure celestial mechanic, he broadened the scientific horizons of the Observatory towards astrophysical studies of the stars, supporting the foundation of the Society of Italian Spectroscopists, the first scientific society dedicated to the new science (Chinnici 2008). The political role of Gasparis and Capocci, both senators of the Kingdom, in the new Italian institutions resulted in a partial renewal of the scientific instruments of the Neapolitan Observatory.
The role of de Gasparis in disseminating astronomical research and discoveries made at Capodimonte was very different from that of Capocci. While his teacher had published volumes and articles to popularize astronomy, de Gasparis was the protagonist of poems and literary works on his planetary discoveries. This is documented by the poems of the magistrate Giovanni Chiaia (1799-1888), the poetess Giovanna Milli (1825-1888), and the Rieti canon Giovambattista de Santis, as well as the dedications of Angelo de Meis (1817-1891) and the prince of Marano, Vincenzo Caracciolo. Recounting de Gasparis' discoveries in verse and prose, these works testify to his unanimously recognized scientific value. Even the humorous newspapers of the time, such as *Arlecchino*, *Il lampione*, and *Il Palazzo di Cristallo*, wrote joking and burlesque articles on de Gasparis and his discoveries. Thus, the astronomer became the protagonist of enigmatic games or indicated as Minister of Foreign Affairs jointly with Plato as Minister of Education and Giuseppe Verdi as Minister of Navy (Gargano 2023).

The social astronomy of Azeglio Bemporad

With the arrival at the direction of the Capodimonte Observatory of Azeglio Bemporad (1875-1945), the initiatives to disseminate astronomy received a further new stimulus. Bemporad was an astronomer with an international background. After graduating from the Scuola Normale in Pisa in 1898, he first became an assistant at the Turin Observatory and then, from 1900 to 1903, at the Astrophysical Observatory Potsdam and Heidelberg-Königstuhl Observatory in Germany, where he collaborated with Max Wolf (1863-1932) taking an interest in celestial mechanics. In 1904, Bemporad became an astronomer at the Astrophysical Observatory of Catania, continuing practical-theoretical research in astronomical refraction and the photometric curves of some variable stars. Furthermore, he was involved by Annibale Riccò (1844-1919), director of Catania Observatory, in the extraordinary project of "Carte du Ciel". His patient measurements and reduction of over 4000 plates made it possible to obtain the positions of 174,107 stars, published in the *Catalogo Astrofotografico per la zona di Catania* (Astrophotographic Catalog for the Catania area) in 64 issues between 1907 and 1942 (Chinnici 2022).
In 1912, he was appointed as director of the Observatory of Capodimonte, where he continued to reduce data of the photographic plates taken in Catania. A convinced supporter of the New Astronomy: Astrophysics, Bemporad had to fight against the Neapolitan scientific environment still tied to the traditional studies of position astronomy. In addition to addressing the scientific activities of the Observatory toward stellar astrophysics, he encouraged the presence of pupils and students in Capodimonte to facilitate school teaching. In 1915, he wrote to Bruno Cotronei (1863-1937), superintendent of the schools of Naples, asking him to solicit "the professors

of physics in the high schools and technical institutes of Naples to lead their students to visit the observatory at least once a year to have an idea (clearer than they can learn from books) of those elements of astronomical geography that form an essential part of the physics program... very unknown to the teachers themselves" (Bemporad 1915). Despite the difficult period of war, due to the partial occupation of the Observatory by military engineers to position lookouts, spotlights, machine guns, and cannons in anti-aircraft function, the schools arrived in Capodimonte to attend didactic lessons of Bemporad and other astronomers of Capodimonte. In addition, many citizen groups and some associations, both Neapolitan and not only, requested visits, observations, and meetings at the Neapolitan observatory. In 1916, Bemporad also wrote to Melania D'Abro Pagratide (1857-?), Inspector of the Regina Elena hospital and the Carminiello territorial hospital of the Italian Red Cross, inviting her to "lead the convalescent soldiers in small numbers (15 or 20 to maximum) to visit this Observatory [to] show Venus… the spots of the Sun… with explanations proportionate to the average of the cultural level of the military". In the letter, Bemporad stressed that about 5,000 convalescent German soldiers had visited the Heidelberg Observatory in 1915: "As usual, therefore, we arrive late, but always on time since the war is far from over" (Bemporad 1916). With the conclusion of the First World War, the appointments in the Observatory with schools (Fig. 3), associations, groups, and astronomy enthusiasts had a substantial increase in the belief that the Observatory also had a moral and social function. Bemporad wrote in a letter that a lady "told me that the Brera Observatory in Milan is strictly forbidden for the public to enter the evening visits. Here too, it was before my arrival. I wanted to change the rules because the government manages the Observatory, and we all pay taxes!" (Bemporad 1927).

Fig. 3: Visit of the Royal School for Women "Eleonora Fonseca Pimentel" of Naples during the Festival of the Trees on 26 April 1929. In the foreground is Azeglio Bemporad, who gave an outdoor lecture for the students. Credits: ASOC, *Album Fotografico*, 1

Social communication of astronomy for generations YZA

In 1989, CERN in Geneva tested a new protocol for data communication: HTTP. It was an effective way to transmit and share experimental data and scientific results. As this technology has become accessible to everyone for free, how people interact on a global scale has also changed. First, the hypertext sites, then the thematic blogs and search engines, and nowadays the vast and varied social media ecosystem has transformed the traditional way of accessing information. The communication and dissemination of scientific knowledge have also found new and more direct ways to address the public. Researchers involved in these activities have experimented with new approaches to train and educate children born between the end of the last century and the first decades of the

third millennium: Millennials, Zoomers, and Generation Alpha.

The digital ecosystem plays a significant role in disseminating scientific knowledge and the most relevant results in the different fields of the STEM (Science, Technology, Engineering, Mathematics) disciplines. Vast literature and proven effectiveness of its use have led to the development of an articulated science of communication that allows scientists and science communicators to build effective strategies to reach different types of users, also modulating the type of content they intend to circulate (Fontaine et al. 2019).

The long and incisive tradition of the Naples Observatory in teaching and scientific communication, briefly described in the previous sections, has allowed the Capodimonte astronomers to adapt the dissemination of astronomy to the new ways of disseminating information, balancing the scientific rigor of contents and communicative effectiveness. In the middle of the second decade of the third millennium, the Neaples Observatory opened its social channels on Facebook, Instagram, YouTube, Twitter, G +, and Flickr platforms. Later, it focused its communication on the first three social media platforms. The constant interaction with users, the publication of scientific content that arouses curiosity and interest, and the promotion of educational activities and multidisciplinary initiatives have allowed the social pages of the Capodimonte Observatory to grow steadily over time. In addition to the traditional credibility and reliability of the research conducted by the oldest scientific institution in Naples, the social pages offer users and astronomy enthusiasts a clear and compelling tool to interact directly with researchers.

From the data collected on 25 May 2024, the Facebook (Fb) and Instagram (Ig) pages of the Observatory of Capodimonte have 22821 and 3080 followers, respectively, while the YouTube channel (Yt), essentially dedicated to sharing the scientific seminars, interviews and public conferences, has 599 subscribers. Comparing that performances with similar pages, which have 5.300 (Fb) and 1.600 (Ig) followers on average, these numbers make the Capodimonte Astronomical Observatory the research institute by far the most followed among all the departments of the National Institute for Astrophysics, of which the Observatory is part. The Fb page of Capodimonte Observatory has about 25% followers of the INAF page and 3 times that of Cagliari Observatory. Moreover, it has also more followers than all the institutes of the Italian research bodies present on social platforms. Even the coverage of the contents proposed on the Observatory's social pages indicates numbers of constant and growing attention. In the period 25 May 2021-24 May 2024, the pages covered 1.127.358 (Fb) and 13.454 (Ig) people, while in the period 5 March 2012-24 May 2024, the contents of the Yt channel were viewed by 209.985 users. Even the audience of followers on the Fb and Ig platforms shows a distribution that indicates a strong interest in the content offered in the age groups between 25 and 45 years, with a prevalence of female audiences, 62% (Fb) and 60% (Ig). Based on the kind of communication and audience, it is possible to estimate potential followers to grow to 37600.000 - 44.200.000 users.

Despite having a distinctly local diffusion, the social pages of the Naples Observatory intercept followers from many other Italian cities and, albeit with small percentages, reach the interest of users residing in other European countries (e.g. 0.5% United Kingdom, 0.4% Franch, Germany, and Spain on Fb and 0,6% Spain, 0,4% Franch, Germany on Ig) than in other continents (e.g. 0.2% United States on Fb and 0,4% Brazil on Ig). The analysis of the posts, which range strictly from scientific topics to astronomical phenomena and social events, also shows how broad the interest of social media users is. The astronomical posts on Facebook with the most impressions are the photo of a shining spring full Moon (26

Fig. 4a: The Golden Moon of 26 May 2021 rose from the slopes of Vesuvius in the most viewed post of the Capodimonte Observatory ever. The photo, taken by the astronomer of Naples Enrico Cascone, was also published by other social pages, such as those of the US Consulate in Naples and Scabec, reaching over 200 thousand fb users.

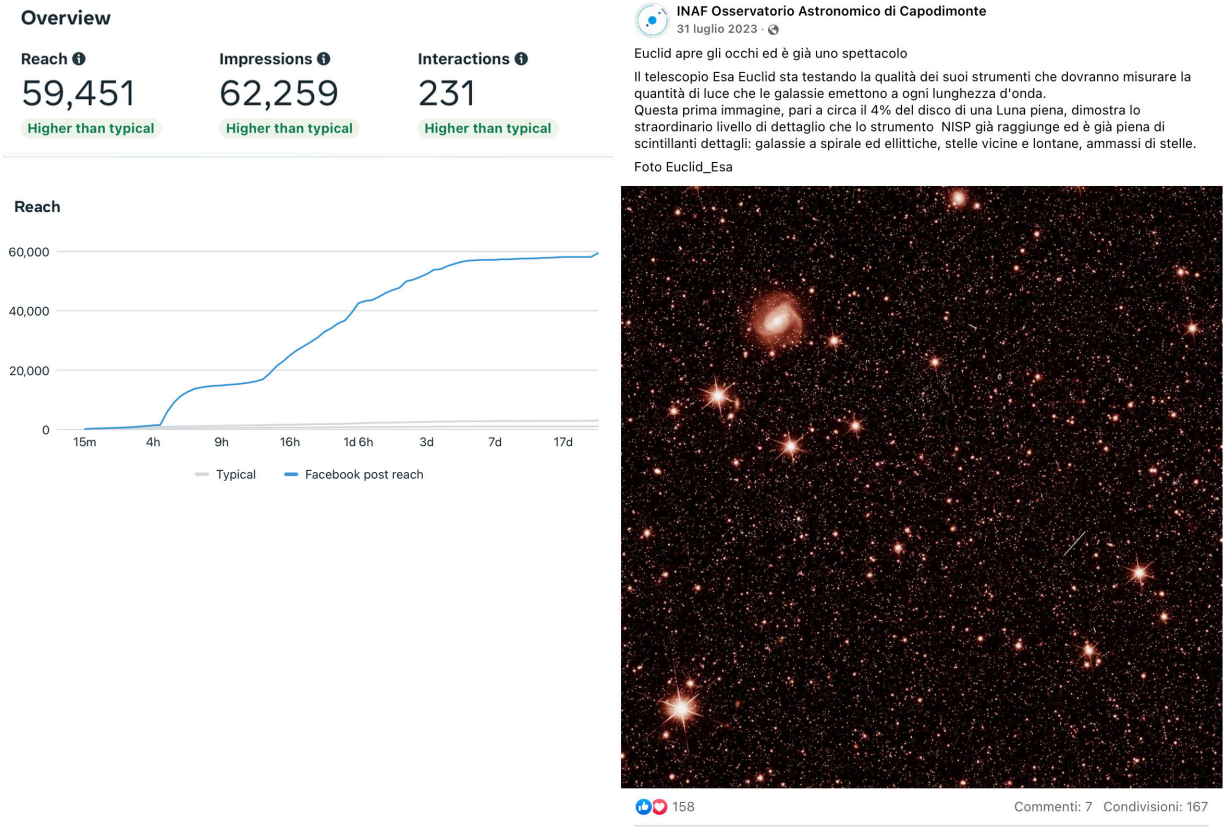

Fig. 4b: "Euclid opens his eyes and it's already a spectacle" is the title of the Fb post about the first light of the Esa space telescope. The post reached about 52500 people in three days.

Fig. 5: A well-attended scientific conversation by Margherita Hack held in the Auditorium of the Capomonte Observatory on 2 September 2003 on the occasion of Red Planet Night; Mars had reached its minimum distance from Earth, approximately 55.7 million km. Credits: Astronomical Observatory of Capodimonte.

May 2021) seen by about 97500 people (fig. 4a), and the first image of the European space telescope Euclid (31 July 2023) with 59.387 people reached and 62.211 visualizations (fig. 4b). But the post with the most impressions and visitors on the Observatory's Fb page is related to a dramatic social event: the death of a promising young musician, killed by a 16-year-old during a parking dispute (1 September 2023) with 658.285 people reached and 691.042 visualizations. On the Observatory's Ig page, however, the first three posts concern the European Researchers' Night (24 September 2023), the late tribute to Piero Angela (13 August 2022), and the official assignment of the new director of the Observatory (12 January 2024), with 1914, 1874, 1557 impressions respectively (data from Meta insight @oacn.inaf).

The interest in astronomical topics on social platforms will certainly not replace the curiosity to look at the sky with a telescope, take a lesson at the planetarium, and explore the museum and ancient library collections. Nevertheless, social communication acts as a multiplier effect. The increasing number of followers on social media is associated with a growing request to visit the Observatory. It is testified by the over 6000 students who participated in the educational activities, the three monthly dissemination and cultural initiatives attended by 250/300 people per evening event (Fig. 5). In the pandemic period, a large turnout of visitors to the *Stelle di Re* (Royal stars) exhibition[5], in 2021. Added to this is, the vast echo of the scientific themes presented in the radio program: *Notizie dallo Spazio* (News from Space), broadcast live weekly on a local radio since September 2020, and the collaboration with the Bellini Theater in Naples, from 2023, with the column *Il cielo sopra il Bellini* (the sky over the Bellini) in *The Belliner* magazine, in which astronomers write about peculiar and engaging astronomical topics, demonstrate that, in summary, the stars and astronomers of Capodimonte continue to be unbeatable influencers.

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[5] In addition, a virtual exhibition was also created (available at: http://stelle-di-re.inaf.it), and the catalog *Stelle di Re* (Napoli, 2021) and the manuscript of the poetess Giuseppa Guacci (1807-1848), wife of the astronomer Antonio Nobile (1794-1863): *Lettere di Michelangelo al padre: ovvero la celeste dottrina dell'astronomia*, (Napoli, 2021) were also published.

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The Marine Strategy in Campania region (Southern Italy): monitoring of Audouin's Gull (*Ichthyaetus audouinii*) breeding colonies over the period 2018 - 2023

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Abstract

The first nesting of Audouin's Gull *(Ichthyaetus audouinii)* in Campania was observed in 1993 along the southern coasts of Cilento. After an irregular beginning, with a reduced number of pairs, the situation has become more stable, also due to the colonization of Phlegrean and Sorrento-Amalfi coasts, starting from 2006, whereas in the first years of 2000s, the species resulted extinct in Cilento. Since 2006, nesting has been regular over the years, although the number of pairs, colonies, and sites changed over time. The number of breeding pairs has decreased, while the adult population seems stable. In some cases, this phenomenon could be due to the high disturbance of colonies by natural predators and human activities.

Keywords: Audouin's Gull, breeding, Campania Region, Marine Strategy

Riassunto

La prima nidificazione di Gabbiano corso *(Ichthyaetus audouinii)* in Campania è stata osservata nel 1993 sulle coste del Cilento meridionale. Da allora, dopo un inizio caratterizzato da una certa irregolarità e da un numero molto ridotto di coppie, la situazione si è stabilizzata, anche a seguito della colonizzazione delle coste flegree e sorrentino – amalfitane a partire dal 2006, mentre a partire dai primi anni del 2000, la specie risulta estinta in Cilento. Dal 2006 la nidificazione è stata regolare negli anni, sebbene il numero di coppie, di colonie e di siti è variato nel tempo. Si registra un calo del numero di coppie riproduttrici a fronte di una popolazione di adulti che sembra invece stabile. Un fenomeno che potrebbe essere dovuto sia ai predatori naturali che ad attività

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Introduction

The Audouin's Gull (*Ichthyaetus audouinii)* is a monotypic and Holomediterranean species, with a European population estimated at 15,700-21,000 pairs (Burfield et al. 2023), with the highest concentration in Spain. Other consistent colonies are located in Algeria, Italy, Greece and France. The number of breeding pairs has been declining from the 25,000 estimated pairs in 2007 to the current above-mentioned estimates, a phenomenon related to the collapse of the main and most numerous colonies of this species, located at the Ebro Delta in Spain. The rapid decline of the Ebro colony, however, coincided with the colonization of new areas throughout the Western Mediterranean and Southern coasts of Portugal, and with the increase in breeding pairs of pre-existing colonies (Brichetti & Fracasso 2018; Keller et al., 2020; BirdLife International 2020).
BirdLife International recently re-evaluated the European Red List category for this species, transferring it from "Least Concern - LC" status, assessed in 2015, to "Vulnerable – VU" status in the 2021 review (BirdLife International 2021). In the fourth assessment of the SPEC (Species of European Conservation Concern) status, BirdLife International classified the species as SPEC1. This category is attributed to species whose status is critical at global level and concerns the species throughout its planetary range (Burfield et al. 2023). The recent Italian Red List, on the other hand, shows a better situation for our country with a change from the category "Near Threatened – NT", assessed in 2012, to the category "Least Concern – LC" in 2019 (Gustin et al. 2019). In the Campania Red List, the species is considered as "Endangered – EN" (Fraissinet & Russo 2013).
In Italy the Audouin's Gull is a regular migrant, partially sedentary and regular breeder (Brichetti & Fracasso 2018; Baccetti et al. 2021). ISPRA estimated a breeding population of 1330 pairs for 2014, distributed in 15 colonies (Nardelli et al. 2015; Brichetti & Fracasso 2018).
In Campania it is a resident breeder, a migrant and a winterer (Fraissinet & Usai 2021). It began nesting in 1993 with a few breeding pairs on the Cilento coasts of Capo Palinuro and Infreschi (Milone 1999; Serra et al. 2001). The breeding activity continued irregularly in the second half of the 1990s, still in Cilento, gradually becoming more regular. In 1994, 1995 and 2001 a pair nested on Infreschi Coast, while in Capo Palinuro 3 pairs nested in 1997, none in 1998, 1- 2 pairs in 1999 and 8 in 2000 (Serra et al. 2001; Milone and Finamore 2002 and 2003). In 2006 nesting was ascertained on Ischia Island with the observation of 8 pairs, at least 4 of which reached the eggs hatching with a minimum of 6 fledged juveniles, and the presence of 17-39 individuals (Usai pers. Obs.). On the other hand, there are no more nesting records in Cilento and it is believed that the species does not breed there since the first half of the 2000s decade (Fraissinet and Russo 2013; Usai in Fraissinet, 2015). In 2007, were counted 14 active nests on Ischia island, with at least 18 fledged juveniles and up to 50 adults and sub-adults individuals (Usai 2007). In 2008, 20 pairs were documented with 25 fledged juveniles (Cavaliere 2009). In 2010, 85 individuals were surveyed at two sites in a

monitoring session on July 21, with 28 juveniles (A. Usai and E. Esse pers. comm.). Since 2007, the nesting has also been detected on Isca and Vetara islets off Punta Campanella. The first documented nesting occurred in 2007, with at least one pair and two juveniles, one of which fledged (Russo and Fulgione 2010). In 2008, 4 pairs and 6 fledged juveniles were detected, while in 2010 there were 9 active nests, doubling those of previous years, and up to 21 individuals at the same time in June 17, while the fledged juveniles were 11-13 (Corbi et al. 2008; Cavaliere et al. 2011). In 2014 a small colony also established on the island of Vivara (Usai in Fraissinet 2015).
The ARPA Campania, in implementation of the Marine Strategy and the consequent task of marine monitoring, signed an agreement with A.S.O.I.M. to monitor the breeding colonies of the Audouin's Gull starting from 2018. The agreement provides for the sampling activities and the compilation of the relative methodological sheets. This has allowed for constant monitoring along the Campania coasts during the breeding season. This paper reports data collected during the 6 years of monitoring.

Materials and Methods

The monitoring protocol of the Marine Strategy, during the breeding season involves a survey by boat along all regional coasts potentially suitable for hosting the species. All rocky coasts of Campania are covered: the Cilento coasts, the Phlegrean archipelago and the continental Phlegrean coasts, the Sorrento-Amalfi coastline with its islets, and the island of Capri. The censuses were carried out from the sea, aboard boats provided by ARPA Campania, and from the land. Surveys by boat involved the circumnavigation of the islands and the inspection of rocky coastlines suitable for nesting, keeping the boat about 50 meters from the shore, or 100-150 meters along high coastlines and cliffs. The censuses were scheduled according to the reproductive and phenological knowledge about the species (Brichetti & Fracasso 2018; Usai in Fraissinet 2015). Surveys were carried out in May and June, when the activity in the colony is at its highest and includes the incubation and hatching of eggs, before the fledging of chicks; generally, each colony was monitored twice within the same breeding season. No counts of chicks were made at the nest to avoid disturbance to the broods of a species experiencing a critical state of conservation.

Results

Despite considerable variation in the number of pairs and colonies location, the Audouin's Gull reproduced in Campania regularly during 2018-2023 (Fig. 1). The colony on Vivara Island has been the only breeding site of this species in Campania from 2018 to 2020. Since 2021, a gradual colonial abandonment of this site and the recolonization of two historical sites on the nearby Ischia island and on the Isca islet have been observed. In 2022 the Audouin's Gull successfully reproduced in Ischia and probably in Vivara with a single pair, while the Isca colonial site was abandoned as a result of strong anthropogenic disturbance during the establishment of the colony. In 2023 Vivara and Isca have not been occupied and the Ischian colony has decreased, but a fair number of adults - 117 - and 4 ascertained pairs (probably 6), were found on the islet of San Martino, located in the Phlegraean Fields, not far from the coast once connected to this islet by a bridge. The colony used both natural ledges on the tuffaceous ridge and some abandoned buildings (Tab.1).
The percentage of breeding adults out of the total number of adults in the colony ranged from 46 to 59%, with a sharp decrease in 2023, when only 8% of adults have bred.
All breeding sites found over the 2018 -

Fig. 1: Localization of breeding colonies on the Campania coasts in the period 2018 – 2023

Table 1: Population and reproduction trends during 2018-2023 at the colonial sites (AC: adults present in the colony; BP: breeding pairs).

	2018		2019		2020		2021		2022		2023	
	AC	*BP*	*AC*	*BP*	*AC*	*BP*	*AC*	*BP*	*AC*	*BP*	*AC*	*BP*
Vivara	180	57	121	33	126	135	8	2	14	1	0	0
Isca	0	0	0	0	0	0	32	12	0	0	0	0
Ischia – Punta della Signora	0	0	0	0	0	0	45	18	53	9	85	4
San Martino	0	0	0	0	0	0	0	0	0	0	117	4
Tot	180	57	121	33	126	135	85	32	67	10	202	8

2023 period are located along the coasts of Naples province. Some adults were observed along the coasts of southern Cilento during this period, but no nesting has ever been detected.

Discussion

Despite heavy urbanization and anthropogenic disturbance, the coasts of the Campania region offer some stretches suitable for nesting. All colonial sites are located in Special Areas of Conservation (SAC) of Natura 2000 protected areas net; furthermore, all of them fall within the boundaries of protected areas of the national and regional system of parks and reserves, as shown in Table 2.

Despite fidelity to breeding area, (Lambertini 1993, Serra et al. 2001; Martínez-Abraín 2003), in Campania the Audouin's Gull has shown a defined turnover among different colonial

Table 2: The table shows the different protection systems of the territories in which the Audouin's gull colonies in Campania fall.

Colonial site	*SAC code and Italian denomination*	*Other protected areas of Italian system of parks and reserves*
San Martino	IT80330013 Isolotto di San Martino e dintorni	Parco Regionale dei Campi Flegrei
Vivara	IT80330013 Isola di Vivara	Area Marina Protetta "Regno di Nettuno"
Ischia – Punta della Signora	IT80330026 Rupi costiere dell'isola di Ischia	Area Marina Protetta "Regno di Nettuno"
Isca	IT80330006 Costiera amalfitana tra Nerano e Positano	Area Marina Protetta "Punta Campanella"

sites over the years;

The Vivara colony abandonment in 2021 coincided with the general collapse of the regional population and the recolonization of Ischia and Isca historical sites, after 8 and 11 years, respectively. The abandonment and recolonization of colonial sites is possibly due to the increase of predators and parasites caused by the growth of the colony itself over the years (Serra et al. 2001), or by dispersal movements (Martínez-Abraín 2003), or, as in the case of Isca in 2022, to a persistent human disturbance due to construction work on the other side of the islet and fishing and water sport activity during the colony establishment. The recent colonization of the San Martino islet could mark the beginning of an increasing occupation of synanthropic habitats, a phenomenon already observed in other Italian locations, for example the Apulian sites (Authors' personal obs.).

The conservation over the years of a fair number of adults in colonies, although only half breeding, leads to the conclusion that the coasts of Campania are trophically suitable,

The conservation over the years of a fair number of adults in the colonies, although only half are engaged in reproductive activities, leads us to consider the Campania coastal area suitable from a trophic point of view. The phenomenon of frequent changes of location should be explored further, checking whether there may also be an anthropic cause.

Once the work was completed, the new monitoring for the 2024 breeding season recorded the return of the colony to the island of Vivara and the movement of the Ischia colony to another location on the island, as well as the absence of nesting on the islet of San Martino. Confirming the species' well-known capacity for turnover in the choice of reproductive sites.

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The Marine Strategy Directive (2018/56/EC) established a framework for community action in the field of marine environmental

policy. Enforced by Legislative Decree no. 190/10, it has entrusted to the Ministry of the Environment the task of implementing marine monitoring, in agreement with the Italian network of environmental agencies: ARPA – ISPRA. In order to fully implement the Monitoring Programmes, referred to the Ministry Decree of 11 February 2015, were introduced activities for the monitoring of marine species and habitats listed under Annexes I, II, IV, V of the Habitats Directive (92/43/EEC) and seabirds species under the Birds Directive (2009/147/EC). Among planned activities for the Campania Region there are the monitoring plans of the Audouin's Gull (*Ichthyaetus audouinii*). Since 2018 ARPA Campania has been supported by the collaboration with A.S.O.I.M. - Associazione Studi Ornitologici Italia Meridionale (Southern Italy Ornithological Studies Association) through a special agreement, which provides sampling activities and methodological sheets. The Marine Strategy monitoring programs entrusted to ARPA Campania funded this research, whose technical staff collaborated with ASOIM researchers, using ARPA 's nautical means.

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A review of knowledge on Dragonflies and Damselflies in the Regional Nature Reserve "Foce Volturno – Costa di Licola"

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Abstract

Based on studies conducted on the Odonata of Campania between the 1980s and 1990s, the Authors have updated the list of species present in the wetlands of the Regional Natural Reserve "Foce Volturno - Costa di Licola", located between the provinces of Caserta and Naples (Campania, Southern Italy). The compilation of the check-list was conducted through bibliographic research in texts and databases, along with new surveys in the sites and initiating citizen science projects. In total, 22 species were recorded (23.1% of Italian species and 39.2% of Campanian species as of 2022), including 7 belonging to the Damselflies and 15 to the Dragonflies. Referring to the regional Odonate fauna list of 1995, 18 species are confirmed (32.14% of those reported in Campania and 18.9% of those reported in Italy as of 2022). In addition to these, *Selysiothemis nigra* and *Brachytron pratense* were sampled by the Authors for the first time in the Reserve area, and *Orthetrum trinacria* was observed by a citizen scientist for the first time at the regional level, data relevant to their national distribution. The contribution provided brings the total number of Odonata species in Campania to 58 and represents the first piece of an ongoing investigation into species richness at the regional scale.

Keywords: Odonata, Wetlands, Campania, Checklist, Volturno.

Introduction

The number of endangered Odonata species globally, according to the latest update of the IUCN Red List as of December 9, 2021, has reached 40.084 species out of a total of 142.577 listed on the IUCN Red List (Kuhn 2021).

The disappearance of Dragonflies is a consequence of the destruction of their habitat, primarily consisting of wetlands that provide essential ecosystem services but are disappearing at a rate three times faster than that of forests (Neri 2021). It is necessary to implement coordinated actions at regional, national, and international levels to prevent these valuable insects from extinction. These organisms are effective bioindicators for assessing anthropogenic disturbances and variations in terrestrial and aquatic ecosystems (Corbet 1980; Mendes et al., 2017; Miguel et al., 2017; Oliveira-Junior & Juen, 2019; Silva et al., 2021a, b). Sampling Odonata is useful for assessing the status of water bodies when the application of the ecological status indices prescribed by the Water Framework Directive (2000/60/EC) is not required (Golfieri et al., 2012).

The high sensitivity of Odonata to environmental changes (Oertli 2008; Rodrigues et al., 2016) is a characteristic attributable to their bifasic life cycle, characterized by an aquatic larval stage and an adult winged stage. This makes them key models in studying impacts or modifications in both aquatic and terrestrial habitats (Oertli 2008; Oliveira-Junior et al., 2013; Carvalho et al., 2018). The quality of sediments in the water influences Odonata populations (Nasirian 2017): contaminants and metals (Cr, Cu, Mn, Zn), associated with coastal and transitional wetland environments (Olsen et al., 1982), can bioaccumulate in the tissues of Odonata species (Nasirian 2017; Jumaat & Ab Hamid, 2023), making them a taxon frequently used in bioindication contexts. The difference in size between the suborders *Zygoptera* and *Anisoptera,* which implies a different selection of their respective habitats, is crucial for identifying disturbances in aquatic systems (Corbet 1999; Remsburg et al., 2008; Calvão et al., 2013; Monteiro-Júnior et al., 2013). Lower temperatures seem to favor a higher percentage of smaller individuals belonging to the *Zygoptera* group, while higher temperatures tend to favor species with larger bodies, belonging to the *Anisoptera* (May 1976; Corbet 1999; Calvão et al., 2013; Carvalho et al., 2013; Calvão et al., 2018). The reduced dispersal capacity of many *Zygoptera* species can make them more dependent on local conditions and therefore more specialized in terms of habitat requirements (Tscharntke et al., 2002). The naturalistic value of these organisms is also derived from the fact that they are the main predators in freshwater ecosystems, both during the larval and adult stages (Sánchez-Herrera & Ware, 2012).

The trend of Odonata communities in Italy is declining, with declining populations outnumbering expanding populations by as much as five times, and with the main threats identified as pollution and habitat loss (Riservato et al., 2014a). Based on this, there is an urgent need to survey species throughout Italy and subsequently monitor the percentage of the global population of each species present in the national territory, in order to identify conservation priorities (Riservato et al., 2014b). With the knowledge of the odonate fauna available at the local level, it is possible to develop management methodologies that will prove useful also at the national scale.

This study aims to summarise investigations on this group of insects, with the first objective being the compilation of an updated and extended check-list covering the entire territory of the Regional Natural Reserve "Foce Volturno - Costa di Licola", in order to verify the presence of species previously reported and report any new ones. Previous knowledge regarding the Odonate fauna of the Protected Area should not be considered exhaustive as contributions related to this area are rather scarce. After an initial study conducted by D'Antonio in 1983 limited to the Variconi area, a check-list was published in 1986 listing 15 species, including *Lestes*

virens vestalis, *Lestes dryas*, *Sympetrum meridionale*, and *Aeshna mixta*. In 1995, D'Antonio published the first and only check-list of Odonata in Campania, reporting a total of 54 species with a *Zygoptera/Anisoptera* ratio of 1:1.3. Although there are historical regional publications for central and southern Italy (Grandi 1957; D'Antonio 1985; Carchini & Rota, 1986), this systematic monitoring represents the first attempt made to accurately evaluate the actual distribution of Odonata in the territory of the Regional Natural Reserve "Foce Volturno - Costa di Licola".

Study area

The study area concerns the Regional Natural Reserve "Foce Volturno - Costa di Licola," a protected natural area in Campania established since 1993 and covering a total area of approximately 1,425.98 hectares between the province of Caserta and the metropolitan city of Naples (Fig. 1). The Natural Reserve is managed by the regional authority of the same name and stretches along the Domitian Coast starting from the right bank of the River Volturno to the old mouth of Lake Patria. The protected territory spans the Municipalities of Castel Volturno, Villa Literno, and Giugliano in Campania, including a vast mosaic of habitats.

The importance of this Reserve is evidenced by the presence of four Sites of Community Importance established under the "Habitat" Directive 92/43/EEC: Lake Patria (IT8030018), Variconi Oasis (IT8010028), Pine forest of Castel Volturno and Patria (IT8010020 and IT8010021).

The Variconi area is also a Special Protection Area (ZPS IT8010018) under the "Birds" Directive 79/409/CEE and a Ramsar Wetland Site (3IT050) established under the Ramsar Convention of 1971.

In addition to this network of protected areas, there is the naturalistic value of the Wetland Area of "Soglitelle" and the mouth of the Volturno River, environments belonging to the Natura 2000 Network established under Directive 92/43/EEC "Habitat" with the aim of preserving the species and habitats for which the sites have been identified.

The diversity of habitats within the entire Protected Area (Fig. 2), including low sandy shores, Mediterranean scrubland, and wooded areas (Habitat Italia, 2023), promotes the presence of rich biodiversity.

The Wetland Area of Variconi consists of a complex of backdune ponds and flooded meadows located on the left side of the Volturno River mouth, covering an area of 303 hectares. The brackish waters present in the Wetland Area greatly influence the nature of these environments, colonized by halophilic herbaceous vegetation mixed with fragments of Mediterranean scrubland (de Filippo 2020).

Lake Patria, formerly known as *Literna Palus*, is the largest brackish basin of volcanic origin in Campania. The protected area extends for approximately 507 hectares, and the lake is fed by both freshwater streams and a cemented channel connecting it to the sea, introducing saltwater. The vegetation in the area is characterized by the presence of juniper and myrtle scrubland and mastic shrubs (de Filippo 2020).

The Pine forest of Castel Volturno (90 hectares) and the Pine forest of Patria (313 hectares), coastal dune territories of recent formation, are mainly composed of pine trees planted in the 1950s, as well as patches of psammophilic vegetation and Mediterranean scrubland environments (de Filippo 2020).

The Regi Lagni are a network of mostly artificial straight canals, resulting from a canalization project carried out in 1610 to drain the waters of a marshy territory extending approximately 100.000 hectares from the Domitio Coast to the Volturno basin. In 1999, the area was recognized as an artificial water body through legislative decree no.152 and underwent environmental requalification and

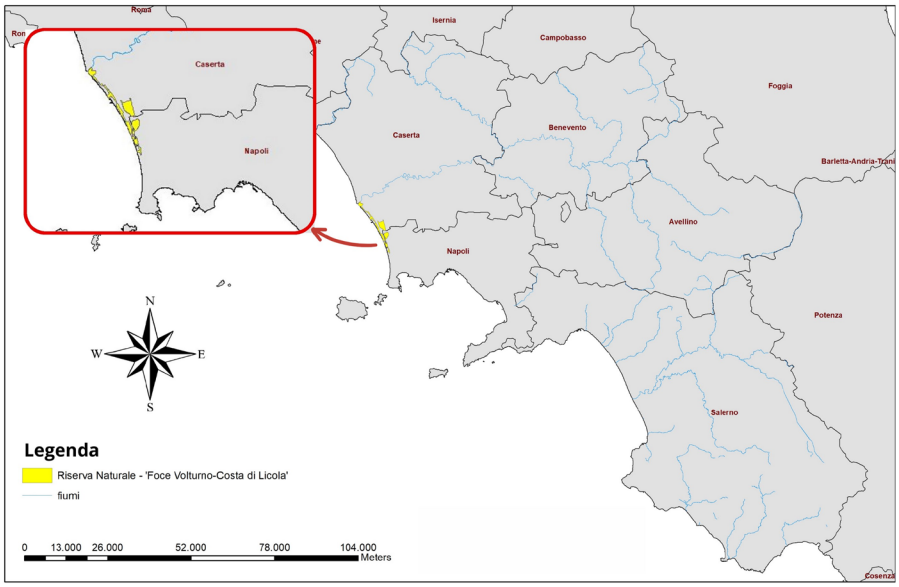

Figura 1. Area of the Regional Natural Reserve "Foce Volturno - Costa di Licola".

Figura 2. Part of the territory of the Reserve: a) the backdune pond of Variconi, b) a glimpse of the landscape in the Wetland Area of "Le Soglitelle," c) Lake Patria, d) the mouth of the Regi Lagni.

remediation in 2009, with the consequent closure and reclamation of many canals.

The wetland area of "Soglitelle" is the site that most recently became part of the Protected Area of the Regional Natural Reserve "Foce Volturno-Costa di Licola". The area consists of a complex of artificial reservoirs created for hunting purposes in the 1970s, seized by the Carabinieri and declared protected in 2006 by the Campania Region, thanks to the efforts of LIPU (Italian League for Bird Protection). A surface area of 100 hectares of land has been expropriated starting from 2012. The reservoirs within this extensive flat surface area

are partly fed by artesian wells, connected to canals that intersect them transversely, all flowing into the larger Vena Canal that runs longitudinally through the site.

Materials and Methods

Knowledge about Odonata in the Reserve was updated by comparing the species list obtained in this study with local and regional check-lists developed respectively in 1986 in the Wetland Area of Variconi and in 1995 in Campania by D'Antonio (D'antonio 1986, 1995). This analysis was supplemented by comparing the obtained check-list with the Atlas of Italian dragonflies (2014), with the Standard Forms of the ZSC of the Natura 2000 Network, and with the most recent check-lists of Odonata in Italy and Campania (2022) obtained from the Odonata.it website, to verify the presence of species sampled by the Authors at the local, regional, and national levels.

Further investigation was conducted using citizen science, particularly with data collected as part of the "Biodiversity RNR Foce Volturno-Costa di Licola" iNaturalist Project, launched by the Fauna Monitoring Station "i Variconi" and "le Soglitelle" (SMFVS) with the aim of determining the check-list of Odonata of the Reserve by updating the species list and identifying the sites of the Reserve most affected by the presence of Odonata.

In addition to bibliographic analyses and contributions from various collaborators through the citizen science platform iNaturalist, field surveys were conducted by volunteer operators of the SMFVS through systematic samplings in the semi-submerged areas of the Reserve. The sampling methodology included: temporary capture of adult specimens with an entomological net, observation and identification with the aid of a camera, and subsequent release of specimens into nature. Field surveys were conducted during the primary activity season of adults, from June to October, to cover the flight periods of all species.

The collected and documented samples were identified based on keys provided by Klaas-Douwe B. Dijkstra and Asmus Schröter (2021). For systematic order, the taxonomy of La Porta et al. (2023) was used. The Atlas of Italian dragonflies by Riservato et al. (2014) was used as a reference for zoogeographical studies.

Results

The conducted samplings reveal the presence of 18 species (Fig. 3), including 4 belonging to the suborder *Zygoptera* (*Calopterygidae*, *Lestidae, Coenagrionidae*) and 14 to the suborder *Anisoptera* (*Aeshnidae*, *Libellulidae*). Below is the list of the 18 species observed during the surveys conducted in 2023 in the area of the Regional Natural Reserve (Tab. 1).

To this list, Coenagrion mercuriale, Ceriagrion tenellum, Aeshna isosceles, and Sympecma fusca are added as species present in the sites of Lake Patria and Variconi, as reported in the Standard Forms of the ZSC (2019), reaching a total richness of 5 families and 22 species present in the Reserve. Among all those surveyed (Fig. 4), Coenagrion mercuriale is included in Annexes II and IV of the Habitats Directive (92/43/CEE) and is considered "near threatened" (NT) in the IUCN Red List of Italian Dragonflies (Riservato et al., 2014), while for all other species, the status is considered "least concern" (LC).

The Atlas of Italian Dragonflies (2014) also reports among the species surveyed in the study area in the 1990s: Cordulegaster trinacriae (the only Italian endemic species and included in Annexes II and IV of the Habitats Directive, 92/43/CEE), Calopteryx haemorrhoidalis, Lestes virens, Lestes dryas, Platycnemis pennipes, Coenagrion puella, Erythromma lindenii, Aeshna affinis, Anax ephippiger, Cordulegaster trinacriae,

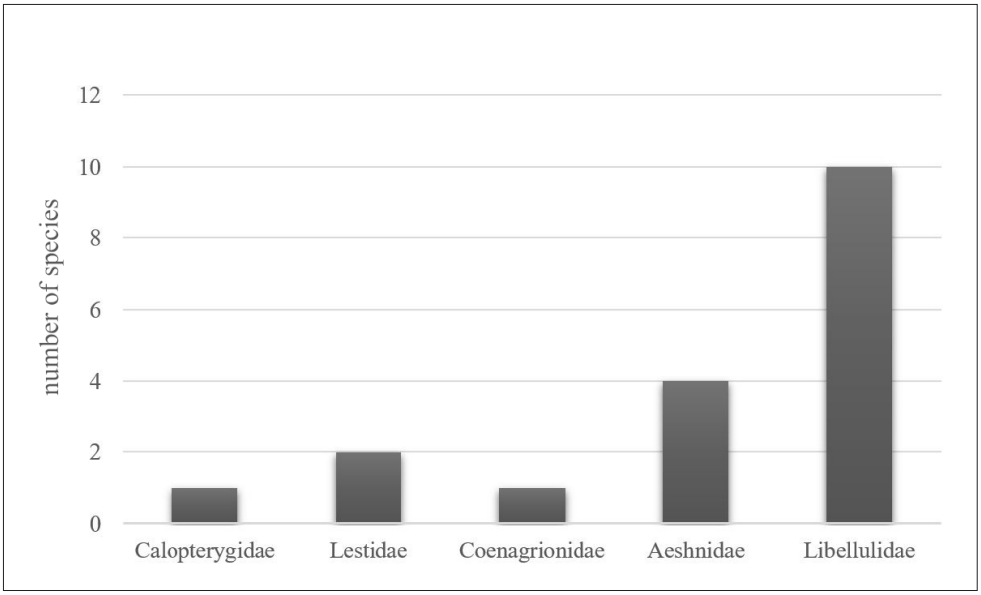

Figura 3. The number of species surveyed in the area of the Regional Natural Reserve by family.

Tabella 1. List of species surveyed during the surveys conducted in 2023 in the Reserve.

Tassonomia	Genere	Specie	Nome Italiano
Zygoptera			
Calopterygidae	*Calopteryx*	*splendens*	Splendente comune
Lestidae	*Lestes*	*barbarus*	Verdina barbara
	Chalcolestes	*viridis*	Verdina maggiore
Coenagrionidae	*Ischnura*	*elegans*	Codazzurra comune
Anisoptera			
Aeshnidae	*Aeshna*	*mixta*	Dragone autunnale
	Anax	*imperator*	Imperatore comune
		parthenope	Imperatore minore
	Brachytron	*pratense*	Dragone peloso
Libellulidae	*Orthetrum*	*brunneum*	Frecciazzurra celeste
		cancellatum	Frecciazzurra puntanera
		coerulescens	Frecciazzurra minore
		trinacria	Frecciazzurra meridionale
	Crocothemis	*erythraea*	Frecciarossa
	Sympetrum	*fonscolombii*	Cardinale venerosse
		meridionale	Cardinale meridionale
		striolatum	Cardinale striato
	Trithemis	*annulata*	Obelisco violetto
	Selysiothemis	*nigra*	Freccianera

Libellula depressa, Libellula fulva, Orthetrum nitidinerve, Sympetrum sanguineum.

Among the various sampling sites within the area of the Regional Natural Reserve "Foce Volturno - Costa di Licola," the wetland area of "Soglitelle" emerged as the area with the highest species abundance (Fig. 5).

Regarding the biogeography of the species recorded in the study area, the majority of the Odonata characterizing the Regional Natural Reserve "Foce Volturno - Costa di Licola" were found to be species with Palearctic

Figura 4. Some of the species surveyed: a) *Aeshna mixta*; b) *Crocothemis erythraea*; c) *Orthetrum cancellatum*; d) *Lestes barbarus*; e) *Sympetrum fonscolombii*.

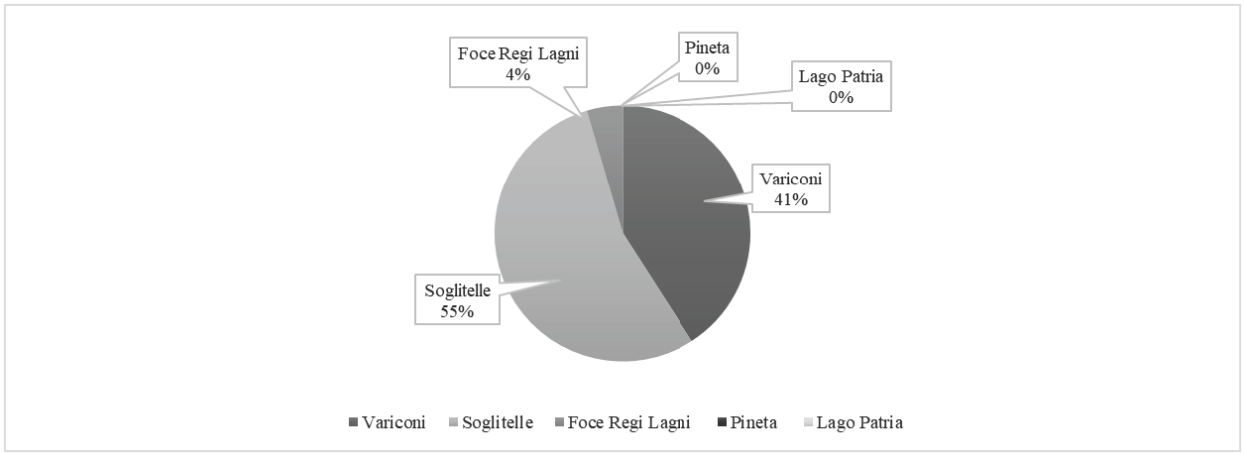

Figura 5. Species richness of Odonata found in the various sampling sites.

distribution (Fig. 6).

The key historical factor that shaped the Odonate fauna of the Palearctic coincides with the periods of glaciation, during which the northern regions were uninhabitable except for the hardiest of odonates, while in the South, greater diversity was confined to a small number of refuges. The most recent glacial period ended approximately 11.700 years ago, from which it is estimated that in most of the Palearctic, the Odonate fauna consists of species that arrived only in the last approximately 10.000 years (Kalkman et al., 2022).

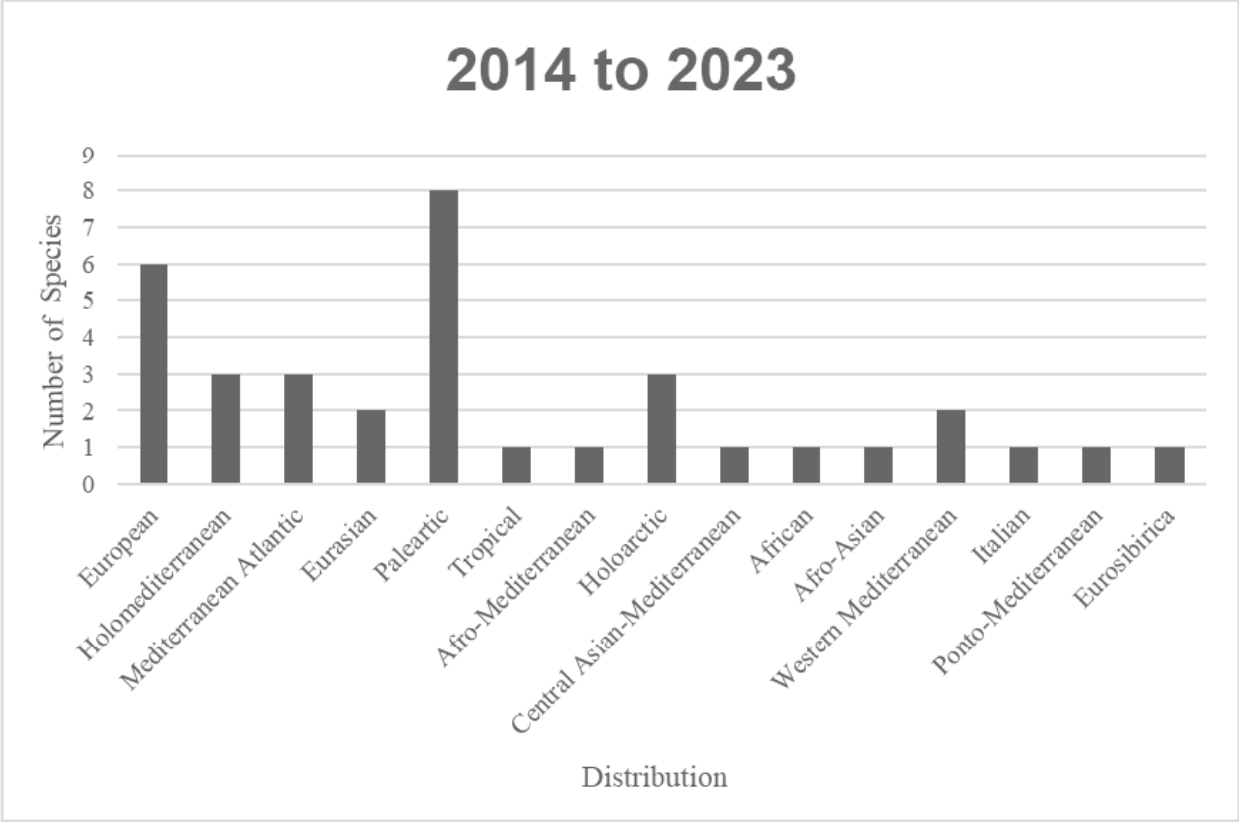

Figura 6. Distribution of the species surveyed throughout the entire area of the RNR from 2014 to 2023.

Discussion

The current distribution of Odonata reflects millions of years of geographic isolation, dispersion, and adaptation to climatic variations, contributing to speciation phenomena and endemism (Samways 1992, 2006). In a globally warming climate, changes in the current biogeography of Odonata are predicted. It is hypothesized that this process will lead to the loss of high-altitude habitat requirements, disadvantaging some specialist individuals (Samways 1992; Stevens & Bailowitz, 2009), while favoring the expansion to higher latitudes of tropical taxa adapted to warmth (Samways 2006). Anisoptera are generally much stronger fliers than damselflies, and most migratory taxa belong to the superfamily *Libelluloidea*. An analysis of biogeographic patterns for the Palearctic region has shown that the biogeographic patterns of *Anisoptera* reflect historical events of vicariance and dispersion, while *Zygoptera*, with relatively limited dispersal, show distributions that appear to reflect more the effect of climate (Heiser & Schmitt, 2010).

This study has returned the expected results regarding species already reported for the territory of the Regional Natural Reserve "Foce Volturno - Costa di Licola" (Guglielmi et al., 2024), with the addition of another 3 species surveyed and not reported in the previous contributions by D'Antonio C. (1986, 1995). The samplings carried out in the various sites of the Reserve allowed the finding of a specimen of *Selysiothemis nigra* in the wetland area of Soglitelle. This species can be observed from mid-May to September, with sporadic and not abundant populations in the national territory, but with an increasing trend suggesting an expansion in the near future (www.iucn.org). Its presence had already been detected by

Figura 7. *Orthetrum trinacria* specimen photographed at Foce Regi Lagni (Photo: Pasquale Liccardo).

Janni et al. (2013) during surveys conducted in the province of Caserta starting from 2005 but is reported as a new species compared to the local odonate fauna of the Regional Natural Reserve "Foce Volturno - Costa di Licola." The Soglitelle wetland area emerged as the most important in terms of species richness at the local level and is probably a hot spot for dragonfly conservation at the regional scale.

In the territory of Variconi, *Brachytron pratense* was found, observable from April until the end of June, and although populations are fragmented, they show a stable trend in the national territory (www.iucn.org). The species had never been reported in Campania before. At the Foce Regi Lagni, the presence of *Orthetrum trinacria* was documented for the first time in the region, thanks to the contribution provided by a citizen scientist. This species can be observed from June to October in stagnant water basins. Its discovery could represent a significant event since the species in Italy was significantly present only in Sicily, Sardinia, and recently found in Calabria (www.iucn.org).

In addition to these three reports, it is also noted among the specimens surveyed the discovery of species listed in the 1995 Campania check-list but not included in the previous local Variconi check-list of 1986: *Orthetrum brunneum*, *Orthetrum cancellatum*, *Orthetrum coerulescens*, and *Trithemis annulata*.

Based on the data provided by this research, the presence of some species observed continuously over the years is confirmed. Considering that the 22 species of Odonata found belong to the different suborders *Zygoptera* and *Anisoptera*, and thus have differentiated ecological needs, it can be stated that the area of the Regional Natural Reserve "Foce Volturno – Costa di Licola" presents a significant biogenetic richness and diversity of environments, indicative of important naturalistic value.

This contribution provides an updated overview of the odonatofauna of the Protected Area, with the perspective of further multi-year sampling aimed at assessing the trends of the populations of the recorded species and possible management interventions to be implemented in case the presence of endangered species is detected. The surveys can also be used as a baseline study in future assessments of aquatic ecosystems. Understanding the ecological dynamics of these organisms can provide useful information for the development of effective conservation and management decision-making processes (Mendes et al., 2017), mostly aimed at maintaining a high level of habitat naturalness.

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