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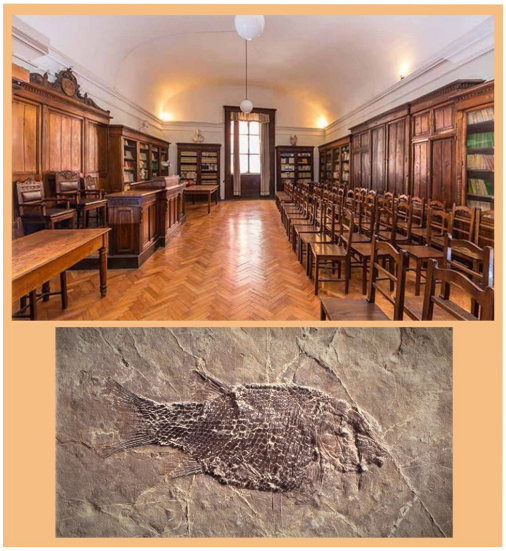

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Nomenclatural remarks on *Galdieria* (Galdieriaceae, Cyanidiophytina, Rhodophyta) with description of three new species and a new lectotypification

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Abstract

Cynanidiophytina are a subdivision of Rhodophyta represented by unicellular organisms often occurring in extreme or acidophilous environments and object of several ecological, physiological, phylogenetic, ontogenetic, and molecular studies. Recently, the genus *Galdieria*, a Cyanidiophytina member that includes four species (out of eleven in the whole subdivision), has been accommodated into a monogeneric order after an extensive taxonomic revision. However, the taxonomy of this group has not been completely assessed. In this contribution, some nomenclatural issues about Galdieriaceae are discussed, three new species are published validating previous names, and revised types supporting the current usage of *Galdieria suphuraria* are presented.

Keywords: Agostino Galdieri, Cyanodiophytina, *Galdieria daedala*, *Galdieria maxima*, *Galdieria partita*, *Galdieria sulphuraria*, typification, nomenclature

Riassunto

Le Cynanidiophytina sono una sub-divisione delle Rhodophyta, costituita da organismi unicellulari spesso presenti in ambienti estremi o acidofili e oggetto di numerosi studi ecologici, fisiologici, filogenetici, ontogenetici, e molecolari. Recentemente, il genere *Galdieria*, membro delle Cyanidiophytina che

comprende quattro specie (su undici dell'intera sub-divisione), è stato inserito in un ordine monogenerico dopo un'ampia revisione tassonomica. Tuttavia, la tassonomia di questo gruppo non è stata completamente valutata. In questo contributo vengono discusse alcune questioni nomenclaturali sulle Galdieriaceae e vengono pubblicate tre nuove specie che convalidano i nomi precedenti.

Parole chiave: Agostino Galdieri, Cyanodiophytina, *Galdieria daedala*, *Galdieria maxima*, *Galdieria partita*, *Galdieria sulphuraria*, tipizzazione, nomenclatura

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Introduction

Agostino Galdieri, born in Fisciano (a small town near Salerno, Campania region, southern Italy), on 15 June 1870, was assistant of the geological cabinet of the University of Naples since 1903 to 1911 (Baraldi & Marocchi, 2021). Later, he was Director of the Institute of Mineralogy of the Agricultural School of Portici, where he was also professor in Geology and Mineralogy (Adamo et al. 2007), but almost none is known of him after that date.

Albeit better known as a geologist, he first described a new eucaryotic alga in the extreme environment of fumaroles of Pozzuoli (Naples, Campania), despite the fact he could not observe its nucleus (Galdieri, 1899). He probably was not the very discoverer of that microorganism, because he cited a "*Protococcus vulcanicus*" gathered in the same place by the better-known Francesco Cesati in 1869, which could be the same alga (Balsamo, 1892). The new taxon was included by Galdieri (1899), with some doubt, in the genus *Pleurococcus* Meneghini (Chaetophoraceae Greville, Chaetophorales Wille, Chlorophyceae Wille), with the name *P. sulphurarius* Galdieri. The taxon was repeatedly gathered in the XIX century (Albertano et al., 2000); however, Merola et al., (1982) first observed that this alga had been misplaced by Galdieri, especially based on its photosynthetic pigments (chlorophyll *a* and C-phycocyanin), which, together with the membrane organization of the chloroplast allow them to recognize a red alga (Sentzova, 1991). On account of its globular shape, reproduction by autospores, presence of vacuole and numerous mitochondria, the taxon was transferred to the new genus *Galdieria* Merola, named in honour of Galdieri and included in the new monotypic family Galdieriaceae Merola (Cyanidiophyceae), then monotypic (Merola et al. 1982). *Galdieria sulphuraria* (Galdieri) Merola is therefore the type of the genus *Galdieria*, which remains the only one of the family but currently includes seven taxa, three of which not validly described (Park et al. 2023).

In fact, some years later, three further *Galdieria* species were described from Russia domains (Sentzova, 1991): "*G. daedala*", "*G. maxima*" (both from Kunashir Island), and "*G. partita*" (from Uzon caldera in

Kamchatka). The three names are regarded as invalid by Park et al. (2023) because of the requirements of the Art. 40.1 of the *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code)* (i.e., Turland et al. 2018. In any case, in her treatment, Sentzova (1991) amended the circumscription of genus *Galdieria* by adding new diagnostic features, such as the facultative heterotrophy. She distinguished the new taxa especially basing on cell size and on shape and number of chloroplasts.

A fourth species, i.e., *Galdieria phlegrea*, was first described by Pinto et al. (2007) who provided a short Latin diagnosis; it differs by the order of nucleotides in *rbcL* (plastid DNA), lacking any reliable difference in morphology and reproduction mechanism from *G. sulphuraria*. It was discovered near Naples in Pozzuoli as well, but in a different place than the *locus classicus* of *G. sulphuraria*, despite in both localities the two taxa are sympatric. Rather unusually, Park et al. (2023), after having enlightened the invalidity of the name by Pinto et al. (2007), did not validate it but re-used it, disregarding the previous authorship, and indicating a different type, actually publishing a new species. Moreover, the type was not gathered in the same locality sampled by Pinto et al. (2007) but in Turkey.

Apart this nomenclatural act, Park et al. (2023), basing on plastid sequences, proposed a revised classification of Cyanidiophytina, accomodating *Galdieria* in a new monotypic order (Galdieriales H.S.Yoon, S.I.Park, C.H.Cho & R.A.Andersen) and describing two new species, i.e., *Galdieria javensis* H.S.Yoon, S.I.Park & R.A.Andersen, first discovered by De Luca et al. (1981) on Mount Lawu in Java (Indonesia), and *G. yellowstonensis* H.S.Yoon, S.I.Park & T. McDermott, from Yellowstone National Park, Wyoming (USA). However, even after their revision, several points remain insufficiently known and, according to Guiry & Guiry (2023), the taxonomic or nomenclatural status of several entities is "in some way unresolved and requires further investigation".

In this contribution, we re-examine the genus *Galdieria* by a nomenclatural point of view, providing the validation of incorrect combinations and propose lectotypification.

Materials and Methods

The relevant literature was examined, paying special attention to the protologues (e.g., Galdieri, 1899; Schwabe, 1936; Merola et al. 1982; Sentzova, 1991; Park et al. 2023). Botanist abbreviations follow IPNI (2023) and Guiry & Guiry (2023), unless differently specified. Original material for untypified names and culture types were respectively searched at NAP (Herbarium of the University of Naples) and at ACUF (The Algal Collection at the University of Naples). The articles cited throughout the text follow Turland et al. (2018) (*Shenzen Code*, hereafter *ICN*).

Results and discussion

The examined names are treated in alphabetical order.

Galdieria daedala – Sentzova (1991) published the name "*Galdieria daedala*" with a description, indication of habitat, locality (Kunashir Island, Kuril archipelago), type, and diagnosis, all in Latin. In this way, she apparently fulfilled the requirements of Arts. 40.1 (indication of type), 44.1 (employ of

Latin language) and 44.2 (accompanying illustration) for names of non-fossil algae published after 1 January 1958; of Art. 40.6 (explicit inclusion of the word "typus" or equivalent) for names published after 1 January 1991; and of Art. 40.7 (indication of collection or institution in which the type specimen is conserved) for names published after 1 January 1990. Therefore, despite the statement by Park et al. (2023), "*G. daedala*" is not at all a "nomen nudum" (= "without any diagnosis or description", see Glossary of *ICN*). However, a serious issue effectively occurs for the valid publication of the name: the type, as defined by Art. 8.4 of *ICN*, "may not be living organisms or cultures"; cultures of algae can be accepted as types "if preserved in a metabolically inactive state (e.g., by lyophilization or deep-freezing to remain alive in that inactive state)". To this regard, we note that on, or after 1 January 2019, "the protologue must include a statement that the culture is preserved in a metabolically inactive state". Sentzova (1991) indicated as the type a collection by L. M. Gerasimenko, which might be considered a specimen as defined by the Art. 8. However, even omitting that this collection might not be a single gathering as required by the footnote of Art. 8.2 (because the gathering time was extended from August to November 1988), if the type statement is compared with the information at page 70 of the same work (Sentzova, 1991), it is clear that such a "type" was a living culture, surely not in an inactivate status. We might consider also the Art. 40.5 of *ICN*, which allows as the type of a microscopic alga an effectively published illustration even after 1990 (in this case, the figure A1 at p. 74 of Sentzova, 1991), but this is granted only "if there are technical difficulties of specimen preservation or if it is impossible to preserve a specimen that would show the features attributed to the taxon by the author of the name". These conditions, however, seem come against the fact that the diagnosis of "*G. partita*" is largely based on morphological traits (Sentzova, 1991) and no difficulty has been stated for fixation of *Galderia*. More important, the figure of "*G. partita*" in the original publication (Sentzova, 1991) is not explicitly associated with the word "type" and cannot be regarded as such (the association between the figure and the word "type" is mandatory after 1 January 1990: Arts. 40.3 and 40.6 of *ICN*). We have therefore to conclude that the name "*Galdieria daedala*" has not been validly published. The University Federico II of Naples preserves a strain of "*G. daedala*" corresponding to the material described by Sentzova (1991) and sent years ago by her to the Department of Biology (at that time Department of Plant Biology). In this way, it is possible to validate the name by her fulfilling all the requirements reported above.

Galdieria maxima – For this name, we can repropose the same observations already made for "*Galdieria daedala*". The corresponding taxon was first gathered in the acid thermal sources of Kunashir Island and published by

Sentzova (1991) according to the same scheme followed for "*G. daedala*".

Galdieria partita – Sentzova (1991) published the name "*Galdieria partita*" with a description, indication of habitat, locality (Kamtchatka in Asian Russia, Yellowstone Park in the US), an intended "type" and diagnosis, all in Latin. Also in this case, the protologue failed in type indication (see discussion about "*G. daedala*") and the name must be validated, eventually indicating as the holotype a specimen originated from the Russian strain obtained by Sentzova.

Galdieria phlegrea – The Art. 40.1 of *ICN* imposes that, on or after 1 January 1958, any name of a new taxon is not validly published unless the indication of its type. In addition, the Art. 40.6 of *ICN* provides that "on or after 1 January 1990, indication of the type must include one of the words "typus" or "holotypus", or its abbreviation, or its equivalent in a modern language". Pinto et al. (2007) evidently did not indicate a type specimen as defined by Art. 8.1 of *ICN* and the question is if in their protologue it is indicated as type a strain preserved in a metabolically inactive state according to Art. 8.4. It is to be noted that still in 2007, under particular conditions, an illustration could had been employed as type; however, any illustration or a reference to a published illustration is missing in Pinto et al. (2007) as well. These authors indicated instead an "authentic strain", i.e., the "strain number 291". Although that strain is not cited as the holotype, it is clear from the context that such "authentic strain" is the real "type" strain. Effectively the word "type" is printed soon after the description of that strain and clearly refers to it, as it reports the *locus classicus* of the species, from where evidently the "authentic strain" was derived. Unfortunately, also in this case, the examination of the text clarifies that the "authentic strain" is a culture and not a specimen, so coming in contrast with Arts. 8, 40.1, 40.6 and 44.2 of *ICN*.

Galdieria sulphuraria – Galdieri (1899) published the name *Pleurococcus sulphurarius* without a classical scheme. He reported first the locality ("Solfatara di Pozzuoli") and observations about macroscopic appearance of the substrate coating caused by the alga (which are effectively notes on the alga itself), of its habitat, ontogeny, physiology, and taxonomic notes. The protologue is entirely in Italian, a language allowed at that time (Art. 44.1, Note 1 of *ICN*). The name appears only one time in the middle of the relation, which can be considered as the protologue (Art. 6.13, footnote). Galdieri provided also illustrations of the new taxon (Figs. "a–i"), which can be regarded as a single plate and obvious original material for lectotypification purposes (Art. 9.4 (b)). The combination *Galdieria sulphuraria* apparently was not validly published by Merola et al. (1982), because they should provide a full and direct reference to the basionym according to Art. 41.5 (this is mandatory since 1 January 1953). In particular, they seem to have failed in page indication (Art. 41.6). However, a reference to the pages is provided at the end of their

contribution (Merola et al. 1982, p. 194); this form is explicitly recommended against by the *ICN* (see Rec. 41A.1), but it does not make the combination invalid by itself. A more serious problem is that the reference encompasses all the pages of the contribution by Galdieri (1899). Nevertheless, as said above, the whole contribution by Galdieri can be quietly regarded as coextensive with the protologue (Art. 40.1, Note 1), because only dedicated to the description of morphology of *Pleurococcus sulphurarius,* illustrations, references, geographical data, discussion, and comments. Accepting as valid the new combination in Merola et al. (1982), the typification proposed by those authors appears as problematic. In fact, in the same paper, they indicated an "iconotypus" (i.e., the illustration in Galdieri 1899) and designated a "neotype" (cultures or specimens by Galdieri being lost since long time). It is clear from the context that "iconotypus" is to be intended merely as indication of "illustration accompanying the protologue" or "illustration of the type material studied by Galdieri". Differently, Merola et al. (1982) would have proposed two different elements as designed types, one by Merola and co-authors (the illustration) and the other one by Merola only (the neotype): this would make ineffective both designations, because Art. 7.11 of *ICN* provides that "designation of *a* type is achieved only if *the* type is definitely accepted as such by the typifying author". On the other hand, if the "iconotypus" indication is not intended as a typification attempt, the proposed neotype cannot be accepted. In fact, a neotype can be selected only if original material is not available (Art. 9.13 of *ICN*). This is obviously not the case, because at least the illustration in Galdieri (1899) is original material itself (Art. 9.4 of *ICN*). For this reason, a lectotypification of the Galdieri's name is still due. In addition, designation of an epitype would be appropriate according to Art. 9.9 of *ICN*, because *Galdieria phlegrea* cannot be distinguished from *G. sulphuraria* only by means of morphological traits (Pinto et al. 2007, Park et al. 2023). Finally, Galdieri (1899, p. 162, footnote 2) cited a "material" of "*Protococcus vulcanicus*" preserved by F. Balsamo. However, this material cannot be regarded as a syntype (Art. 9.6 of *ICN*), which would claim priority in lectotypification (Art. 9.12 of *ICN*). In fact, Galdieri, writing that that material could not be compared with those collected by him, did not associate it to the name: "è impossibile tenerne calcolo" (= "it is impossible to take it into account"). In any case, this material is now lost as well.

Nomenclatural synopsis of *Galdieria*

Galdieria Merola in Giorn. Bot. Ital. 115(4-5): 193. 1982 ["1981"]. Generitype: *Pleurococcus sulphurarius* Galdieri [≡ *Galdieria sulphuraria*] (designated by Merola in Merola et al. 1982: 193).

***Galdieria daedala* Sentzova ex Pollio, De Natale & Del Guacchio, spec. nov.**

Diagnosis: Ab omnibus speciebus congeneribus chloroplastis daedalis variiformibus, necnon forma autosporarum matricalium differt. In omnibus vitae gradibus intimum stratum parietis cellulae exsertum versus membranam plasmatis.

Description: Cells globose or almost so, 2.5–8.0 µm in diam., growing under mixo- and heterotrophy up to 10.0 µm. Chloroplast one, parietal, with envelope labyrinth-shaped in autospores and young cells, plurilobate in mature cells. Autospores 4–8–16. In all stages of the cell life the innermost layer of the cell wall protruded towards the plasma membrane. Membrane of parent cells enlarged to the shape of autospores, empty and lentiform (both diagnosis and description are modified from Sentzova 1991: 75).

Holotypus: NAP, barcode NAP0002462, prepared in 4% formalin from the living strain ACUF 133, isolated from URSS, Kamtchatka, Uzon and sent by O. Ju. Sentzova.

Illustration: Figure 1 (A-C) from the holotype (present study); additional illustrations in Sentzova (1991: 74, figs. «B» 1-11) and in Pinto et al. (2003: 22, figs. 26-27).

Galdieria javensis H.S.Yoon, S.I.Park & R.A.Andersen, in J. Phycol. 59: 452. 2023. Type (holotype): No. 02667126 (NY), from culture strain NIES-3638; isotypes at NY (No. 02667127), SKK (No. SKK003971), MABIK (No. MABIK_AL00089917) (Park et al. 2023: 452). Illustration: Fig. 2j in Park et al. (2023: 451).

Galdieria maxima **Sentzova ex Pollio, De Natale & Del Guacchio, spec. nov.**

Diagnosis: A speciebus ceteris *Galdieriae* magnitudine, chloroplasto semper reticulato differt.

Description: Cells globose. After any nutrition 6.0–16.5 µm in diameter. Chloroplast single, net-shaped. Autosporae 2–4–8, irregularly globose or conical. Membrane of parent cells empty and bag-shaped (both diagnosis and description are modified from Sentzova 1991: 75).

Holotypus: NAP, barcode NAP0002463, prepared in 4% formalin from the living strain ACUF 132 from URSS, Kamtchatka, Uzon and sent by O. Ju. Sentzova.

Illustration: Figure 1 (D-F) from the holotype (present study); additional illustrations in Sentzova (1991: 74, figs. «Б», 1-9) and in: Pinto et al. (2003: 23, Figs. 30-31).

Galdieria partita **Sentzova ex Pollio, De Natale & Del Guacchio, spec. nov.**

Diagnosis: *Species* Galdieriae daedalae *dimensionibus cellularum similis est sed ab ea et speciebus congeneribus forma chloroplastorum recedit*.

Description: Cells globose, 2.5–8.0 µm in diameter, growing by mixo- and heterotrophy up to 11.0 µm. Chloroplast parietal, always single and cup-shaped in autospores, always single and belt- or dumbbell-shaped in young cells, one and subdivided in many elongate, sac-like elements in mature cells, which they almost completely cover. Autospores 4–8, conical. Membrane of parent cells

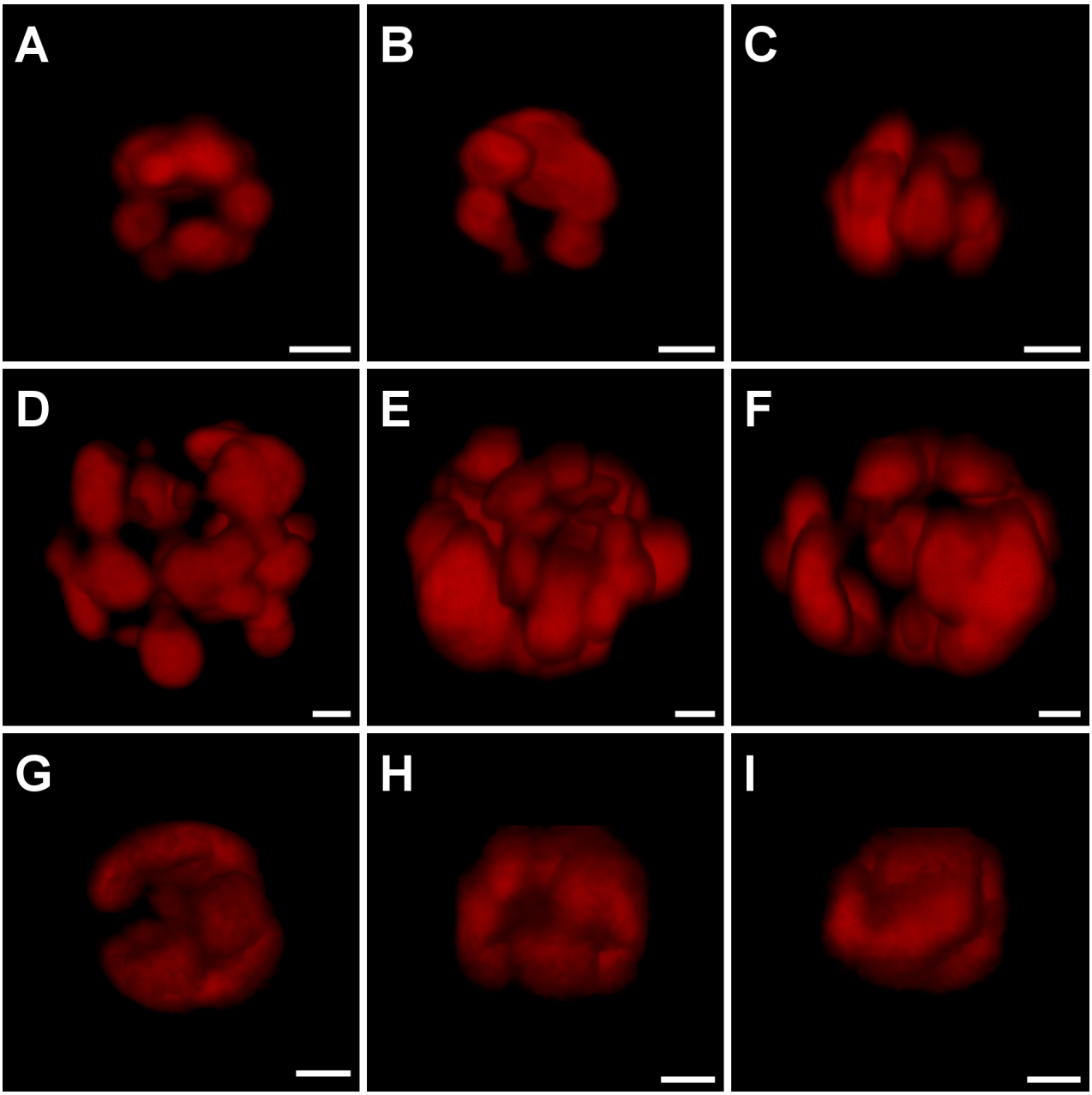

Figure 1: Reconstruction of chloroplasts using CLSM autofluorescence images (Z-stack), views in the direction of the three axes X, Y and Z. *Galdieria daedala* (A-C), *G. maxima* (D-F), *G. partita* (G-I). Scale bar 2 µm.

empty, lenticular or bag-shaped (both diagnosis and description modified from Sentzova 1991: 73).

Holotypus: NAP, barcode NAP0002464, prepared in 4% formalin from the living strain ACUF 131 from Kunashir Island, and sent O. Ju. Sentzova.

Illustration: Figure 1 (G-I) from the holotype (present study); additional illustrations in Sentsova (1991: 74, figs. «A» 1–14); and in Pinto et al. (2003: 22, Figs. 28-29).

Galdieria phlegrea H.S.Yoon, S.I.Park & Ciniglia, in J. Phycol. 59: 452. 2023.

Type (holotype): No. 02667128 (NY), cells from culture strain 629 S; isotypes at NY (No. 02667129), SKK (No. SKK003972), MABIK (No. MABIK_AL00089919). Illustration: Fig. 2h in Park et al. (2023: 451).

Notes: Claudia Ciniglia can be abbreviated as "Ciniglia", since she is the same author of the invalid name "*Galdieria phlegrea* Pinto, Ciniglia, Cascone & Pollio", in Seckbach, J. (ed.), Algae and Cyanobact. in extreme environ.: 501. 2007; Antonino Pollio is wrongly cited in Guiry & Guiry (2023) as "Pollo".

***Galdieria sulphuraria* (Galdieri) Merola** ≡ *Pleurococcus sulphurarius* Galdieri, in Rendiconti Reale Accad. Sci. Fis. Ser. 3, 6: 162. 1899. (basionym). Type (lectotype here designated):–figure [1:] a-i in Galdieri (1899: 161). Epitype (here designated):–NAP, barcode NAP0002465, prepared in 4% formalin and originated from Naples (Italy), Pozzuoli Solfatara.

Galdieria yellowstonensis H.S.Yoon, S.I.Park & T.McDermott, in J. Phycol. 59: 452. 2023. Type (holotype): No. 02667130 (NY), from culture strain HSY245; isotypes at NY (No. 02667131), SKK (No. SKK003973), MABIK (No. MABIK_AL00089918). Illustration: Fig. 2i in Park et al. (2023: 451).

Note: It is not clear if the colonies of *Galdieria* samples at Yellowstone by De Luca et al. (1981, under of *G. sulphuraria*), as well as those cited by Sentzova (1991, under *G. partita*) are to be referred at least partially to this taxon.

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Author contributions

Conceptualization: E. Del Guacchio and A. De Natale

Dara curation: A. De Natale

Writing – original and final draft preparation: E. Del Guacchio and A.Pollio

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Recent human-bear conflicts in Northern Italy: a review, with considerations of future perspectives

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Abstract

The killing of a runner in Northern Italy by a brown bear (*Ursus arctos arctos*) and the subsequent investigation of such matter highlighted a Human-Wildlife Conflict (HWC) that has been present in Trentino since the introduction of bears for conservation during the *Life Ursus* Project. Such conflict may be exacerbated as both human and bear populations get bigger. In this paper, I summarize the information we have about the WHC in Trentino, the attacks on humans and the legal procedures available. Several trends (e.g., increase of problematic bears) were already noticed and predicted in the past. The current legal instruments do not strictly define what a "dangerous bear" is, which lead to very subjective measures. Unless mitigation solutions are adopted (e.g., bear spray) or expanded (e.g., communication on the subject), WHC may disrupt the work done until now for bear conservation in the Italian Alps, due to a negative perception from the local population, which seems to be amplified by local politicians.

Keywords: Conservation, HWC, Italy, Trentino, Bear, attack

Riassunto

L'uccisione di un runner nell'Italia settentrionale da parte di un orso bruno (*Ursus arctos arctos*) e l'investigazione che ne è seguita hanno evidenziato il conflitto uomo-natura (Human-Wildlife Conflict, HWC) presente in Trentino sin dall'introduzione degli orsi per motivi conservazionistici durante il Progetto *Life Ursus*. Tali conflitti potrebbero esacerbarsi nel momento in cui entrambe le popolazioni (umana e ursina) aumentano di dimensione. In questo articolo, riassumo le informazioni che

abbiamo riguardanti il WHC in Trentino, gli attacchi agli umani e le procedure legali disponibili. Diverse tendenze (per esempio, l'aumento di orsi problematici) sono state notate e predette già in passato. Gli attuali mezzi legali non definiscono in maniera stretta cosa sia un "orso pericoloso", il che porta a misure altamente soggettive. A meno che non siano adottate soluzioni per mitigare il conflitto (per esempio, lo spray anti orso) o altre soluzioni già presenti non sono migliorate (per esempio, la comunicazione sull'argomento orso), il WHC potrebbe danneggiare in maniera irreparabile il lavoro fatto finora per la conservazione degli orsi nelle Alpi italiane, a cause di una percezione negativa da parte della popolazione locale, la quale sembra essere amplificata dai politici locali.

Parole chiave: Conservazione, conflitto uomo-natura, Italia, Trentino, orso, attacco

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Introduction

The brown bear (*Ursus arctos*) was once widespread in its circumpolar range, but it became locally extinct in several North American and European areas during the 19th and 20th Century, due to direct and indirect (e.g., accidental road kills coupled with habitat loss and fragmentation) human persecution (Kaczensky et al., 2011, 2013; Tosi et al., 2015; McLellan et al., 2017; von Hardenberg, 2017). This led to the decline of several local populations, especially in Europe (Linnell et al., 2008; Tosi et al., 2015; McLellan et al., 2017, von Hardenberg, 2017). Generally, Human-Wildlife Conflicts (HWC) between human and bears (Ursidae) arise because of the overlap between human settlements or resources (e.g., flocks or beehives) and bear ranges, which can lead to potential encounters and competition between the two; e.g., the bear feeds upon resources used by humans such as livestock, beehives and ungulates or human leftovers in trash bins (Linnell et al., 2008; Kaczensky et al., 2011, 2013; Tosi et al., 2015; Penteriani et al., 2016, 2020; von Hardenberg, 2017; Støen et al., 2018, 2020; Bombieri et al., 2019; Krofel et al., 2020). Such conflicts hindered conservation and rewilding plans in the past, while also impeding bear dispersal and connectivity among metapopulations (Kaczensky et al., 2011, 2013; von Hardenberg, 2017; Corradini et al., 2021).

One of the most notorious WHC with bears arises when these animals attack humans (see Penteriani et al., 2020 for a review on such a subject). Brown bears attacking humans are generally thought to be rare (Tosi et al., 2015; Bombieri et al., 2019; Penteriani et al., 2020), especially in Europe; from 2000 to 2015, roughly 18 attacks per year have been reported in the continent, with 8 of such yearly attacks reported in Romania only (Bombieri et al., 2019). However, attacks tend to be more frequent where the bear population density increases (Linnell et al., 2008; Tosi et al., 2015; Støen et al., 2018; Bombieri et al., 2019; Penteriani et al., 2020; ISPRA-MUSE, 2021). Furthermore, media coverage may exacerbate or exaggerate the risk posed by predator

attacks (Tosi et al., 2015; Penteriani et al., 2016; Bombieri et al., 2018, 2019; Lennox et al., 2018) and it would lead to perceive such animals as something to remove (e.g., Tosi et al., 2015; Lennox et al., 2018). For mitigating such conflicts, removal or culling of dangerous individuals is proposed for calming down the general population (Krofel et al., 2020; ISPRA-MIUR 2021), although such approaches are becoming less popular, and the efficacy of removal is questioned (Lennox et al., 2018; Human-Bear Conflicts Expert Team of the IUCN SSC Bear Specialist Group, 2019).

Given the increase of both human and bear populations, it is plausible that WHCs, including bear attacks, may increase if precautions are not taken (Tosi et al., 2015), as shown by a recent example from Northern Italy: on 5 April 2023, a jogger was mauled by a European brown bear (*U. arctos arctos*) in the Autonomous Province of Trento (Trentino-Alto Adige/Südtirol region, also known as "Trentino"). That was the first bear-caused fatality in Italy in modern times (Giuffrida, 2023a; Tondo, 2023). Genetic analyses seemed to find a female individual known as "JJ4" as the culprit and such bear was captured on 17 April (Giuffrida, 2023a; Salvatori, 2023; Tondo, 2023). JJ4 was already known due to her attack on two other people in 2020 (ISPRA-MIUR, 2021; Groff et al., 2020, 2022; ISPRA, 2023; Tab. 1) and for a false attack on a cyclist (Groff et al., 2023): given her recidivism, the governor of the Autonomous Province of Trento ordered the culling of the bear (Giuffrida, 2023a). However, the execution was halted after a legal appeal by animal right activists (Tondo, 2023) and a forensic analysis seemed to show that the jogger was actually attacked by a male bear, which led to protests from environmental groups and the request of freeing JJ4 (Giuffrida, 2023b; but see Zamattio, 2023). In addition, the accident sparked a public debate about the presence of the bears in Northern Italy (Ansa, 2023; Nast, 2023; Salvatori, 2023; WWF Italia, 2023; Zamattio, 2023).

Such an event, together with the public coverage it received, highlighted the presence of the HWC in the area surrounding the Italian Alps at a worldwide level. In this paper, I briefly summarize the modern (from 1999 to now) conflicts between bears and humans and the attacks in such areas, while also discussing the current laws and procedures regarding this population and its problematic individuals. I also briefly discuss how the situation may evolve, according to potential measures and the local human population's attitude.

Materials and Methods

For writing this review regarding the story of the project and bear attacks in the region, while also understanding the legal protocol available in Trentino and potential future directions, I researched articles, theses, book chapters, technical reports and news throughout Google and Google Scholar, using English ("bear", "brown bear", "Alps", "Northern Italy", "wildlife human conflict", "mitigation", "attack", "false attack") and Italian ("orso", "orso bruno", "Alpi", "Trentino", "Nord Italia", "attacco", "falso attacco") keywords and the scientific name of the considered species and subspecies. Additionally, I also used the information from the references (i.e., other articles or Italian technical reports) of the considered research articles and book chapters.

Table 1: List of reported bear attacks on humans in Northern Italy from 2014 to 2023. Data from Groff et al. (2015, 2016, 2018, 2021), Tosi et al. (2015), ISPRA-MIUR (2021), ISPRA (2023) and news reports.

Year	Description of the event	Fate of the bear
2014	The female bear Daniza attacked a mushroom collector on 15 August. She was with her cubs.	After being sedated in a capture attempt, Daniza did not recover and died on 11 September 2014.
2015	The female bear KJ2 attacked a jogger and his dog on 10 June. She already started to do several bluff attacks from 2008. She was probably with her cubs, although the presence of the latter was proven only after the attack and not during it.	The bear was caught and equipped with a radio collar.
2017	The female bear KJ2, while she was with her cubs, attacked an elderly man walking his dogs on 22 July.	Given that this was her second attack, KJ2 was culled by forest rangers on 12 August 2017.
2020	The female bear JJ4 attacked two people, a man and his son, on 22 June, around late afternoon. She was with her cubs.	Initially, the province wanted the culling of JJ4. A legal appeal rejected the culling request and JJ4 was equipped with a radio collar.
2020	The 2-years old male bear M57 attacked an off-duty policeman on 22 August, around 10:30 PM.	Given that he exhibited risky behavior before the attack (e. g., following people and eating from trash bins), M57 was caught and he is currently in captivity in Hungary.
2023	The male bear MJ5 attacked a man with his dog on 5 March, around 8 AM.	At the time of the writing of this article, the bear was not caught and removed from the population yet. The province government wanted the culling of the animal, but that was halted by a legal appeal.
2023	A runner was mauled by a bear on 5 April. Initially, JJ4 was accused of the attack. A forensic analysis seemed to indicate that the attack was done by a male individual, which contradicts the genetic analyses.	The circumstances of the attack are still not very well understood, also because JJ4's radio collar was not functioning. JJ4 was caught and she is currently in captivity, managed by the forest rangers. Her execution was halted by a legal appeal.

Results and discussion

From Life Ursus to the current situation: brief story of the current Alps bear population

The brown bear was almost extinct in the Alps in the 20th Century, due to human persecution and activities (Duprè et al., 2000; AA. VV., 2011; Tosi et al., 2015; von Hardenberg, 2017). For reinstating the bears

in this area, a Life project called "Life Ursus" (AA. VV., 2011; Tosi et al., 2015; von Hardenberg, 2017; LIFE Public Database, 2021) was financed to the Adamello Brenta Nature Park in cooperation with the Province of Trento and the Italian Wildlife Institute. For doing so, 10 bears were imported from Slovenia for allowing restocking in 1999: such decisions stemmed from the genetic similarity between Alpine and Slovenia bears (Tosi et al., 2015; LIFE Public Database, 2021).

From a crude matter of numbers, the project is regarded as a success: a minimum vital population (MVP) was established and the economic compensations for WHCs were similar to the expected ones (Tosi et al., 2015; Groff et al., 2018). Regarding the MVP, it was estimated at 40-60 individuals and Tosi et al. (2015) reported that the population would have reached 60-94 individuals by 2017. At least 100 bears were estimated to be present in the area in 2022 (Groff et al., 2023) and more than 130 bears might be present in 2025 (ISPRA-MIUR, 2021), with a potential carrying capacity that may reach 205 according to potentially suitable areas (Tosi et al., 2015). However, the population seems to be isolated from its Slovenian source, potentially due to high density of human infrastructures and activities in low valleys that hinders bear dispersal (Kaczensky et al., 2013; Peters et al., 2015; Corradini et al., 2021). Additionally, it was already noted in Tosi et al. (2015) that the public perception on bears in the area, initially positive, started to switch through a negative one because of some conflicts that the local populations had with the bears (e.g., false attacks by the bears, livestock damages and incursions of bears in human areas), which also lead to illegal killings. Such conflicts (damage events and compensations) increased after the publication of that article (Groff et al., 2018, 2022).

Human-bear WHC: damage and event types

Generally, bear-related damages in the area tend to be on beehives, crops and livestock (Tosi et al., 2015; Groff et al., 2018, 2022, 2023; Corradini et al., 2021). Precisely, damages on beehives accounted for roughly 38% of the damaging events and 39.9% of the bear damages' reimbursement costs, followed by livestock with 35.4% and 35.6%, respectively during the time period 1999-2017 (Groff et al., 2018). Therefore, beehives and livestock damages accounted for 73.4% of the damage events and 75.5% of the compensations. Crops followed suit, with 19.9% of the events and 21.6% of the compensations (Groff et al., 2018). Sheep and goats are usually the most attacked farming animals (Tosi et al., 2015; Groff et al., 2018). These kinds of damages are in line with the usual WHC present with brown bears around the world (Krofel et al., 2020).

In 2022, which is the last year with available data at the time of the writing of this article, the situation was similar: there were 301 cases of damage events by bear activities. However, the Large Carnivore Report shows the data for 150 of them, given that the damage compensation's requests were not all completed (Groff et al., 2023). 105 of the reported events were directed to livestock or poultry, causing the disappearance, the injuring or killing of 364 animals (Groff et al., 2023). In the year before (2021), the damage events were also 301: 113 of these were directed to livestock, causing the disappearance or killing of 572 animals. In

contrast with the period 1999-2017 and the other previous years (Tosi et al., 2015; Groff et al., 2018, 2019, 2020, 2021), poultry was the most impacted vertebrate in the last two available years (Groff et al., 2022, 2023). Crops and beehives were impacted by 68 events each in 2021 (Groff et al., 2022), while in 2022 31 and 46 events were reported for crops and beehives respectively (Groff et al. 2023). Therefore, roughly 83.14% of the damages in the last two available years were related to agriculture or animal farming. In 2021, the damages were compensated with €172,373.94 given to the damaged people and they were the highest reported ever for the area (Groff et al., 2022), although they are still in the range of the expected amount of reimbursement per number of bears (Duprè et al., 2000; Tosi et al., 2015; Groff et al. 2018). The sum dropped to €76.786,51 in 2022, albeit this estimate was not regarded as "definitive" by Groff et al. (2023).

Several bears are also known to be confident in the area and/or to be feeding on anthropic food leftovers: such behavior may lead to having more encounters with humans or even bears that follow people (ISPRA-MIUR, 2021; Groff et al., 2021, 2022, 2023). Additionally, confident bears tend to get close to human settlements (ISPRA-MIUR, 2021) and they may damage human infrastructures (e.g., Groff et al., 2021). For now, damages to infrastructures are the least reported kind of damage in Trentino (Tosi et al. 2015; Groff et al., 2018, 2022, 2023), but confident individuals would probably be the most common "problematic" bears in the area in the future (ISPRA-MIUR, 2021). At least 52 road accidents involving bears have been reported since the start of the project (Groff et al., 2023) and illegal killings started to happen at least since 2013 (Tosi et al., 2015).

The WHCs in the Alps slightly mirrors what happens in another area of Italy, the Central Apennines, between humans and a morphologically and genetically distinct Italian endemic brown bear population (the Apennine bear *U. arctos marsicanus*; Loy et al., 2008; Benazzo et al., 2017; Swenson et al., 2020). The Apennine bear is critically endangered, but it is sometimes illegally killed because it causes damage to the agricultural-farming sector, mostly on livestock (Ciucci & Boitani, 2008). Such killings have been shown to critically slow down conservation attempts (Ciucci & Boitani, 2008; Benazzo et al., 2017). Additionally, habituation caused by food conditioning is reported for the area, which increases the risk of human-bear encounters (Ciucci & Boitani, 2008; Forconi, 2020). However, no attacks on humans are reported from Apennines in modern times (Ciucci & Boitani, 2008; Benazzo et al., 2017) and the bear seems tolerated by the majority of the population, although some people have the feeling that their life is restricted by bear protection (Glikman et al., 2023).

Summaries of bear attacks in Trentino

According to the data from Groff et al. (2015, 2016, 2021), Tosi et al. (2015), ISPRA-MIUR (2021), ISPRA (2023) and news reports (e.g., Ansa, 2023; Giuffrida, 2023a), there were 7 official reported bear attacks on humans from 2014 to 2023 in the Province of Trento (Tab. 1). This equates to 0.7 attacks per year. Such an estimate would furtherly drop if we consider that, from 1999 (the year in which Slovenian bears started to be present in the area) to 2013, no attack on humans has been reported from the region (Tosi et al., 2015;

ISPRA-MIUR, 2021). This change may stem from an increase of both bear and human population densities (Bombieri et al., 2019). Another potential attack is reported in Groff et al. (2015), in which it is written that a man suffered an arm injury after encountering a bear; however, no physical contact between the person and the bear was reported and it is plausible that the man injured himself while running away.

The attacks happened from March to August, with 5 out of 7 happening in summer months (Tosi et al., 2015; Groff et al., 2015, 2016, 2021; ISPRA-MIUR, 2021; ISPRA, 2023). In the attacks in which the culprit is sure (6), 4 of the attacking bears were females with cubs (ISPRA-MIUR, 2021; Tab. 1); such an estimate would increase to 5 out of 7, if JJ4 is confirmed as the culprit of the last attack. That being said, the presence of cubs in the first KJ2's attack was confirmed only afterwards and not during the encounter (Groff et al., 2016). All the attacked people were adult men. On 3 occasions, dogs were present (Tab. 1); however, their behavior was not reported, and it is therefore not possible to make inferences about the relationship between bear attacks and presence of dogs (Bombieri et al., 2019; Krofel et al., 2020). 1 out of 7 attacks was fatal, which is roughly 14.29% of the attacks. Beside MJ5 (Ansa 2023), all the reported bear specimens were captured, although only one (KJ2) was culled (ISPRA-MIUR, 2021). The first reported attacking bear, Daniza, died after being sedated (Groff et al., 2015; Tosi et al., 2015). At the time of the writing of this article, all the other caught bears were in captivity, with one of them (M57) translocated in a shelter in Hungary (Groff et al., 2022). The Autonomous Province of Trento asked for the execution of the other bears, but legal appeals from animal rights groups halted the procedures (Tab. 1).

It is worthy noticing that, if JJ4 is confirmed as the bear of the most recent accident, 4 out of 7 attacks came from 2 bears, which seem to be in agreement with the idea that bear attacks are rare and usually few bears in the populations cause issues (AA. VV., 2011; Tosi et al., 2015; Bombieri et al., 2019; ISPRA-MIUR, 2021). Furthermore, both Daniza and M57 were reported near human settlements, and the latter also followed people before the attack: therefore, they both showed dangerous behavior before attacking people (ISPRA-MIUR, 2021).

Although it is probably premature to draw conclusions from only 7 attacks, the reported data seems to agree with the worldwide trends observed by Bombieri et al. (2019): the majority of the attacks were from females with cubs; the attacks mostly happened during summer, which is the period where human recreational activity increases; the death rate of such attacks is around 14.3%; bears usually attack unaccompanied people, probably because groups are easier to detect and avoid. The majority of the people that get attacked are usually adult men at the worldwide level (Bombieri et al., 2019); in the case of the Alps, adult men represent all the victims (Tab. 1).

Regarding false attacks (i.e., charging without any physical contact), Tosi et al. (2015) reported at least 8 cases during the period 1999-2014, which were mostly caused by females with cubs. From 2015 to 2022, further 16 certified cases were reported by the Large Carnivore Reports (Groff et al., 2016, 2017, 2018, 2019, 2021, 2023). No false attacks were reported in 2019 (Groff et al., 2020), and 2021, although "threatening behaviour" was reported in the

latter year in a single instance (Groff et al., 2022). In 11 of these 16 cases, the charge was surely done by a bear with cubs (Tab. 2), confirming how this category of bear is the one who tends to perform this kind of action (e.g., Tosi et al. 2015). Two of the reported bears, KJ2 and JJ4, also performed "true" attacks (Tab. 1 and 2).

The legislative landscape: the PACOBACE

In the Autonomous Province of Trento, the interregional management protocol for the management of the bear is called PACOBACE (AA. VV., 2011). Such protocol also gives guidelines about how to define a bear "dangerous" for the human population. Specifically, a "damaging bear" is a bear that "repeatedly causes material damage to

Table 2. List of reported bear false attacks on humans in Northern Italy from 2015 to 2023. Data from Groff et al. (2016, 2017, 2018, 2019, 2021, 2023).

Year	Description of the event
2015	On 14 June, an unidentified bear accompanied by three cubs performed a bluff charge.
2015	On 24 July, an unidentified bear with two cubs performed a false attack.
2016	On 13 June, a false attack by two unidentified bears was reported.
2016	On 12 July, KJ2 was reported to engage in false attacks. She was with her cubs (reported as "two-three" in number)
2016	On 24 September, an unidentified female bear with at least two cubs performed a false attack.
2017	On 2 July, a mushroom picker was chased by an unidentified female with a cub for 30 meters.
2017	On 21 July, a woman was chased by a bear. The bear was not identified, but it is hypothesized it was KJ2, given that such encounter happened nearby where this individual attacked a person.
2018	On 6 June, at 8:20 PM, the female bear KJ1 chased a person, who suffered minor injuries while trying to escape. The bear was with her cubs.
2018	On 15 August, a man suffered minor bruises while running away from the female bear F12, which tried to chase the man after seeing him. The bear was with another bear.
2018	On 21 November, a couple heard a siren and a female bear with at least one cub was running and hissing at them. The woman tripped, while her husband let his dog loose, which ran towards the bear. After that, the bear ran away and disappeared. Both the bear and her cub were not identified.
2020	On 12 July, a bear bluff-charged a cyclist.
2020	On 26 August, a bear bluff-charged a jogger.
2020	On 29 August, a bear bluff-charged a forest warden.
2022	On 22 June, JJ4 performed a false attack on a biker. She was with cubs.
2022	On 31 July, a man with his dog was chased by a female bear with a cub.

property[...] or repeatedly uses sources of food linked to the presence of man[...]". According to the protocol, a bear who does single or sporadic damage should not be regarded as "damaging". A "dangerous bear", instead, is less strictly defined and there are several categories of dangerous bears. A scale of dangerousness is used, according to the behavior exhibited by the bear. According to PACOBACE, "the degree of dangerousness increases when there is repetition of potentially dangerous behaviour by the same bear." From a theoretical perspective, each case is evaluated differently (AA. VV., 2011; ISPRA-MIUR, 2021; ISPRA, 2023). It is also implicit that the behaviors regarded as most dangerous are the ones that allow the removal of the animals from the population by the authority (ISPRA-MIUR, 2021).

Bear killing was only allowed after getting authorization from both the Minister of Environment and the Italian Institute for Environmental Protection and Research, ISPRA (AA. VV., 2011); such rule was changed in 2018, and now only a consultation with ISPRA is required, while the province has the power to order the removal, capture or killing of the bears (Groff et al., 2021, 2022). Legal appeal is possible, as shown by the cases of MJ5 and JJ4 (Groff et al., 2021, 2022; Ansa, 2023, Giuffrida, 2023b). ISPRA usually considers culling necessary if prevention and deterrent actions (e.g., rubber bullets and noises) do not work on the considered bears (ISPRA-MIUR, 2021).

The lack of strict criteria and definitions for dangerous bears has been criticized by WWF Italy, which called for reducing subjectivity by applying a more stringent definition of "dangerous" (WWF Italia, 2023). In fact, JJ4 and MJ5 were already ordered by the Autonomous Province of Trento's governor to be put down after a single attack in 2020 and 2023, respectively, before animal right activists' appeals (Groff et al., 2020, 2022; Ansa, 2023; Giuffrida, 2023b). Therefore, the culling requests seem to be in contrast with the "repetition of potentially dangerous behaviour" highlighted by PACOBACE. Critically, JJ4 was regarded as "potentially dangerous" by ISPRA in 2021 (ISPRA-MIUR, 2021) and not strictly dangerous; only after the second offense the animal was regarded as "dangerous" (ISPRA, 2023), although the 2020 culling request by the province came already at the first offense (Giuffrida, 2023b) and also before the false attack it performed (Groff et al., 2022). Other potential examples, Daniza and M57, did not attack multiple people but exhibited different risky behaviors (ISPRA-MIUR, 2021); in such cases, given the seriality of one of the behaviors, the bears should be regarded as "dangerous" without any issue, but it is controversial how many "repetitions" are enough for entering in such a category and if doing different risky behavior equal to a repetition (i.e., if a bear doing two different risky behaviors equals to a bear doing a single kind of risky behavior twice). In the case of KJ2, two attacks on humans were enough for the "dangerous" labeling and the culling (ISPRA-MIUR, 2021).

Potential future directions

The WHC between bears and humans in Trentino will probably increase in future years, given the potential appearance of new problematic bears (ISPRA-MIUR, 2021). In a MsC thesis published in 2021, bear spray was regarded as a potential way to deal with brown bears in the area (Neri, 2021).

Specifically, such measure would be the most transferable (i.e., suitable to the context) in the Trentino area, given that it is the one respecting the majority of the parameters taken in consideration by the Suitability, Feasibility and Acceptability (SFA) framework (Neri, 2021). Other studies showed how this measure may strongly reduce the risk of injury in case of close contact with a bear (Smith et al., 2008). Currently, bear spray is illegal in Italy, due to the concerns about its use as a weapon (Neri, 2021 and references therein), although there are already requests for making it available in the country (e.g., see the discussion about the "Acceptability" of the spray in Neri 2021, and WWF Italia, 2023). The building of wildlife corridors, which would help the species to reconnect with the source population (Peters et al., 2015; Corradini et al., 2021) and would also reduce the bear population density in the Alps (WWF Italia, 2023), seems to not be feasible right now due to cost issues (Neri, 2021).

For what concerns other potential measures, the level of communication and preventions adopted in the Alps has been criticized, particularly the spread of knowledge that would help local communities-bears coexistence and actions that would lead to less confident bears, such as bear-resistant trash containers (Tosi et al., 2015; ISPRA-MIUR, 2021; WWF Italia, 2023). Both actions have been shown to potentially reduce WHC between bears and humans (Krofel et al., 2020). Bombieri et al. (2019) reported the lack of fit activities for increasing the knowledge of the general population regarding bears' activities at worldwide level, especially regarding the presence of females with cubs, which are the category of bears that potentially attack more people. For what concerns bear-resistant bins, although their current amount is not regarded as sufficient (ISPRA-MIUR, 2021), they are currently being implemented and they will increase in number in the future (Groff et al., 2022, 2023).

Prevention measures are also implemented for defending livestock, including livestock guarding dogs (LGD) and electric fences (Groff et al., 2022, 2023). Between 2009 and 2019, an average of €66,956 per year has been spent for prevention in the area; such sums also include prevention from wolf-related (*Canis lupus*) damages since 2012 (ISPRA-MIUR, 2021), although the economic impact of prevention actions for the latter was comparably low from 2012 to 2017 (Groff et al., 2022). In 2022, around €143,600 were spent for such activities (Groff et al., 2023). It would not be surprising if such sum increases in the future, given the potential increase of damaging bears in the next few years.

Furthermore, an analysis based on different stakeholder's opinions is necessary, given that some classes (e.g., shepherds) may see the beard in a less positive way compared to other groups due to potential bear-related damages, as it already happens with the Apennine bears (Glikman et al., 2023). This may also lead to potential proposals about management in the area (e.g., Marino et al., 2021). Critically, the population should be involved in communication, management, and prevention activities as much as possible. Communication activities organized with the direct involvement of the population is especially important, given that such involvement will increase the efficacy of this approach (Krofel et al., 2020). Furthermore, public involvement in bear management can help to make the

population feel both safer and responsible toward bears (Majić et al., 2011; Glikman et al., 2023).

At the same time, the population should be approached for reducing its fear of the bear (e.g., Johansson et al., 2019); a fearful population may be prone to commit illegal killings, hindering conservation practices in the area (Tosi et al., 2015), as it already happened in other European nations (Kaczensky et al., 2011, 2013) and in Italy, both in Central Alps in the past (Tosi et al., 2015; von Hardenberg, 2017; Swenson et al., 2020; ISPRA-MIUR, 2021) and Apennines (Ciucci & Boitani, 2008; Glickman et al., 2023). Reducing the fear toward such animals would be a potential way to even have economic advantages, given that brown bears are potential tourist attractions, and their value would cover the damage costs (Tattoni et al., 2017), although this strategy has caveats associated with it (see Das & Chatterjee, 2015) and it may not be perceived as a benefit by some stakeholders (Glikman et al., 2023).

A negative attitude toward bears may also be influenced by local politicians' attitude, as already noted by Tosi et al. (2015). For example, the current governor of the Autonomous Province of Trento has called for the culling of bears after one single instance of risky behavior (Groff et al., 2020, 2022; Ansa, 2023; Giuffrida, 2023b); as already discussed, this seems in contrast with the PACOBACE. In addition, the governor said that around 50-70 bears need to be relocated (Salvatori, 2023; Zamattio, 2023); such numbers do not seem to correspond to the reality of the population. Precisely, around 19 bears were regarded as dangerous or potentially dangerous between 2005 and 2020; all but 2 individuals were dead or in captivity at that time. Among the living bears, there was JJ4 too (ISPRA-MIUR, 2021). Currently, JJ4 and MJ5 are the alive bear considered by ISPRA (2023) for removal; the individual M62, who was on the list due to overconfident behavior (ISPRA, 2023), died probably because of the attack of another bear (Ufficio Stampa Provincia Autonoma di Trento, 2023). Groff et al. (2022) also reports the female specimen F43 as a "problem bear" due to "overconfident behaviour": however, she died in September 2022, after being sedated by the rangers who tried to change her radio collar (Ansa, 2023; Groff et al., 2023). If the estimates of ISPRA-MIUR (2021) are right, there might be at most around 15 dangerous individuals to be removed from the population from 2021 to 2025. Therefore, the 50-70 individuals cited by the governor seem to be an exaggeration (see also Zamattio, 2023). It is recognized that fear toward predators may be used to promote populist parties (Von Hohenberg & Hager, 2022) and such parties may use fear in general for promoting environmentally unsustainable or unreasonable policies (see Atkins & Menga, 2022, and references therein). Given this, for avoiding potential excessive negative exposure, it is hoped that better local media management is implemented, as suggested by Tosi et al. (2015).

Conclusions

Several measures for limiting bear-human conflicts were proposed in the past and some of them seem to be already enacted (e.g., communication and bear-resistant trash bin); however, such measures seem not to be implemented enough and it is hoped that they will be more used and fine-tuned to the Trentino context in the future. Critically,

communication regarding the risk of meeting a bear with cubs during spring and summer is needed. At the same time, it should be suggested to go in groups during excursions, given that bears seem to mostly attack people who are alone or together with just another person. Calls for the legalization of the bear spray may increase in the future and it is desirable that such a solution would be used, given its efficacy.

In any case, mitigation measures should also consider the Trentino local context and it is absolutely necessary to involve the population as much as possible, given that it could potentially make the bears more accepted by individuals and reduce the possibility of a second conservation failure, after the one in the 20th Century.

The PACOBACE needs to be updated for re-defining what a "dangerous bear" is, given that the current definition is currently too loose and it leads to too much subjectivity. Given the previous case of KJ2 and the presence of a scale of dangerousness, the limit of "dangerous behaviors" could be put at two in case of attacks to humans or any action that would lead to the removal from the population. In addition, the PACOBACE absolutely has to define if two different risky actions done by bears are equal to repetition or if only two offenses of the same behavior are regarded as such.

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Supplementary Data

A preprint, based on the first draft of this article, is available on EcoEvoRxiv (https://ecoevorxiv.org/repository/view/5696/, doi: 10.32942/X2V59H).

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Environmental and geomorphic aspects of urban beaches of Naples, southern Italy

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Abstract

Integrated morphometric, granulometric, and morphoscopic analyses and environmental surveys of six beaches selected from thirty, with different characteristics and lengths ranging from a few to several tens of meters, were carried out since 2019. These sensitive transition environments between sea and land undergo bureaucratic and operational management in mutual transition between many institutions, from central to local, which often results in delayed interventions. The comparison and interpretation of the data and results allowed to outline the main morphosedimentary and geomorphological characters of these beaches, to obtain a modern morpho-typological classification including biotic and anthropogenic elements. These urban beaches can be equated in physiography and sedimentological features to pocket beaches or intermediate types between those and predominantly sandy tombolo, salient and beaches at the cliff foot. Since pocket beaches are the favorite of bathers for their beauty due to high-morphological waterscape variability, they are subject to intense anthropogenic pressure. Current erosion in these artificial environments is less intense than occurring on large natural littorals of alluvial or minor coastal plains but is relevant concerning the limited width and massive seasonal tourist pressure. Urban beaches register a high-risk factor when tourist settlements occupy the backshore. They constitute a natural buffer against undermining the behind cliff foot by storm

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waves. Consequently, the cliff is sheltered and becomes inactive. Sea waves could trigger cliff collapses or seriously damage urban structures on them. Considering the importance that urban beaches have both for a tourist-recreational issue and the safeguard of the cliff and buildings, it is necessary to protect them. Appropriate policies include proper management and targeted removal of the clay material, macroplastics, microplastics, and microfibers massed by waves, sea currents, and wind, as well as from incorrect behavior by users.

Keywords: Coastal geomorphology, urban beach, environmental design, Naples

Riassunto

La ricerca verte sullo studio delle spiagge urbane di Napoli, Italia. Sono stati svolti rilevamenti ed analisi ambientali integrate morfometriche, granulometriche e morfoscopiche di sei spiagge urbane selezionate tra trenta, con caratteristiche diverse e lunghezza da pochi ad alcune decine di metri. Questi sensibili ambienti di transizione tra mare e terra soffrono di una gestione burocratica e operativa in mutua transizione tra molti *stakeholder*, da quelli centrali ai locali, che spesso ritardano gli interventi. La comparazione ed interpretazione di dati e risultati ha permesso di delineare i principali caratteri morfosedimentari e geomorfologici per una moderna classificazione morfotipologica che include anche elementi biotici ed antropogenici. Queste spiagge urbane si possono equiparare per fisiografia ed aspetti sedimentologici a *pocket beach* o tipi intermedi tra queste e tomboli o cuspidi perlopiù sabbiosi e spiagge al piede di falesia. Poiché le *pocket beach* sono preferite dai bagnati per la loro bellezza dovuta ad un'alta variabilità morfologica del paesaggio costiero, sono soggette a stress di genesi antropica elevato. I processi erosivi in atto, seppure meno intensi di quelli dei grandi litorali che orlano le pianure alluvionali o costiere minori, sono rilevanti in relazione all'ampiezza limitata delle spiagge urbane e alla forte pressione turistica stagionale. Queste spiagge registrano un fattore di rischio elevato quando gli insediamenti turistici occupano la zona di retrospiaggia. Inoltre, costituiscono una barriera naturale contro lo scalzamento al piede della retrostante falesia operato dalle mareggiate, che così diviene inattiva. Le onde marine potrebbero innescare crolli della falesia o arrecare gravi danni alle strutture che vi fondano. Data l'importanza che hanno le spiagge urbane per motivi turistico-ricreativi, salvaguardia di falesia e strutture antropiche, è necessario tutelarle mediante una corretta gestione e rimozione mirata dei materiali fittili, macroplastiche, microplastiche e microfibre depositati da onde, correnti marine e vento, nonché a causa del comportamento scorretto dell'utenza.

Parole chiave: Geomorfologia costiera, spiaggia urbana, progettazione ambientale, Napoli

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Introduction

Vanishing beaches originated by different human pressure are a worldwide issue, with significant and sometimes unpredictable socio-economic and environmental impacts (Pezzuto et al., 2006; Donadio 2017; Lämmle et al., 2022a). Almost 90% of America's sandy beaches have been eroding (EPA, 1994), losing up to 15 m of shoreline per year (Blum & Roberts 2009) in the last few decades. In Europe, from 40% to 70% of the shoreline is eroding (Beachmed 2008), but in some cases, the problem is much worse as the concurrent factors multifaceted. Among littorals, the pocket beaches, known also as gravel beaches, are highly endangered by erosion processes and poorly monitored (Sayao 1991; Pranzini et al., 2007; Savi 2007; Simeoni et al., 2012; Bowman et al., 2014; Klumb et al., 2014), different from urban beaches. Currently, these transition environments are not yet classified and rarely studied, despite their relevance for the management of coastal zones, marine space, urban ocean, and littoral dynamics (De Pippo et al., 2003; Pranzini 2009; Blumberg & Bruno 2018; Lämmle & Bulhões 2019; Silva et al., 2021; Lämmle et al., 2022b; Souza et al., 2023).

Considering the city waterscape, urban beaches seem to place at an intermediate morphodynamic type between a beach at the foot of sea cliff and a pocket beach, but in this sense a first fitting classification related also to erosion (Table 1) was proposed by Valente (1999).

This research represents a starting point for classification, further investigations, and projects focused on safeguarding urban beaches. In the next years, these seascapes will be the subject of worldwide research programs, as evidenced by recent reports of IPCC (2019, 2021) on potential effects in islands and cities of the ongoing climate change and coastal resilience (Masselink & Lazarus 2019), as an increase in sea level, flash floods and storm surges.

Geological and geomorphological framework

The city of Naples is in the eastern sector of the Phlegraean Fields active volcanic area (Fig. 1). The hilly morphology is mainly due to the presence of explosive monogenetic volcanoes and rare lava domes, mantled by thick Phlegraean pyroclastic deposits. The landscape was modeled by the down-faulting displacement associated with the collapse of two nested Late Pleistocene calderas (Petrosino et al., 2020). The oldest and largest one is associated to the Campanian Ignimbrite eruption (CI, ~40 ka BP; Giaccio et al., 2019; De Vivo et al., 2001), the youngest, inner one is related to the Neapolitan Yellow Tuff eruption (NYT, ~15 ka BP; Deino et al., 2004).

The presence of small volcanic centers as Mt. Echia and Nisida Island (3.9 ka BP), along the

Table 1: Classification of urban beaches and erosion mitigation mechanism or process (after Valente 1999).

COAST TYPE			MECHANISM OR PROCESS
1	**Urban**		**Imposed**
	a	seafront with defense structures	emerged breakwater
	b	waterfront	quay, wharf
	c	port	port dike, dock
2	**Peri-urban**		**Soft**
	a	waterfront with sparse defense structures	submerged breakwater
	b	peri-urban littoral	artificial nourishment, dewatering
3	**Sub-urban**		**Hybrid**
	a	absence of defense structures	artificial nourishment protected at the foot
			naturalistic engineering interventions
	b	high rocky coast	light and reversible works on the dune

coastline, testifies to recent explosive activity inside the city (Scarpati et al., 2013, 2015). The coast is exposed to Southwest and Northwest sea storms and featured by an alternation of small promontories and coves with some pocket beaches. Fluvial-marine erosion and deposition processes triggered by vertical ground motions and postglacial sea-level fluctuations remodeled the inherited landscape during the last 5 ka (Cinque et al., 2011; Donadio 2019). Several ruins of Roman age are present along the coastland and seabed down to about 6 m of depth between the Castel dell'Ovo (NE) and Nisida Island (SW) (Günther 1913; Simeone & Masucci 2009; Stefanile et al. 2018). These archaeological structures were downlifted by local bradyseismic phenomena still ongoing (Aucelli et al. 2017a,b; Stanislao 2018; Donadio et al., 2019; Pappone et al., 2019). The pyroclastic deposits are dissected by urban streams which supply some urban beaches. The embankments of the 1930s and postwar, the seaward enlargement and artificial progradation of the modern port, Santa Lucia, and Viale A. Gramsci neighborhoods (SE and SW), modified the waterfront (Brandolini et al., 2020). Currently, erosion processes of the tuff sea cliff are mainly due to sea wave action and intense rainfall triggering non-negligible effects on the waterscape. Landslides, flash floods, and accelerated erosion formed rock piles and small coastal alluvial fans in the urban beaches and along the seabed. The anthropic embankments and quarrying contributed to modify the original coastal physiography since the Roman age and especially during the last five centuries. Considering all the geoenvironmental features of the coastland and the waterscape morphology, the presence of straight urban streams, vertical ground motion, sea-level rise, seismicity, active volcanoes in the peripheral areas, the tsunamigenic processes to which this area is prone, and the dense urbanization, the overall geomorphological hazard results from high to extreme as this engineered littoral is a *technocoast* (De Pippo et al., 2002a, 2008, 2009; Anthony 2014; Valente et al., 2014; Ferrando et al., 2021; Clemente et al., 2022).

Naturalistic features

The morphological and sedimentological aspects of urban beaches are currently controlled by the mutual interaction between physical, biotic, and anthropic

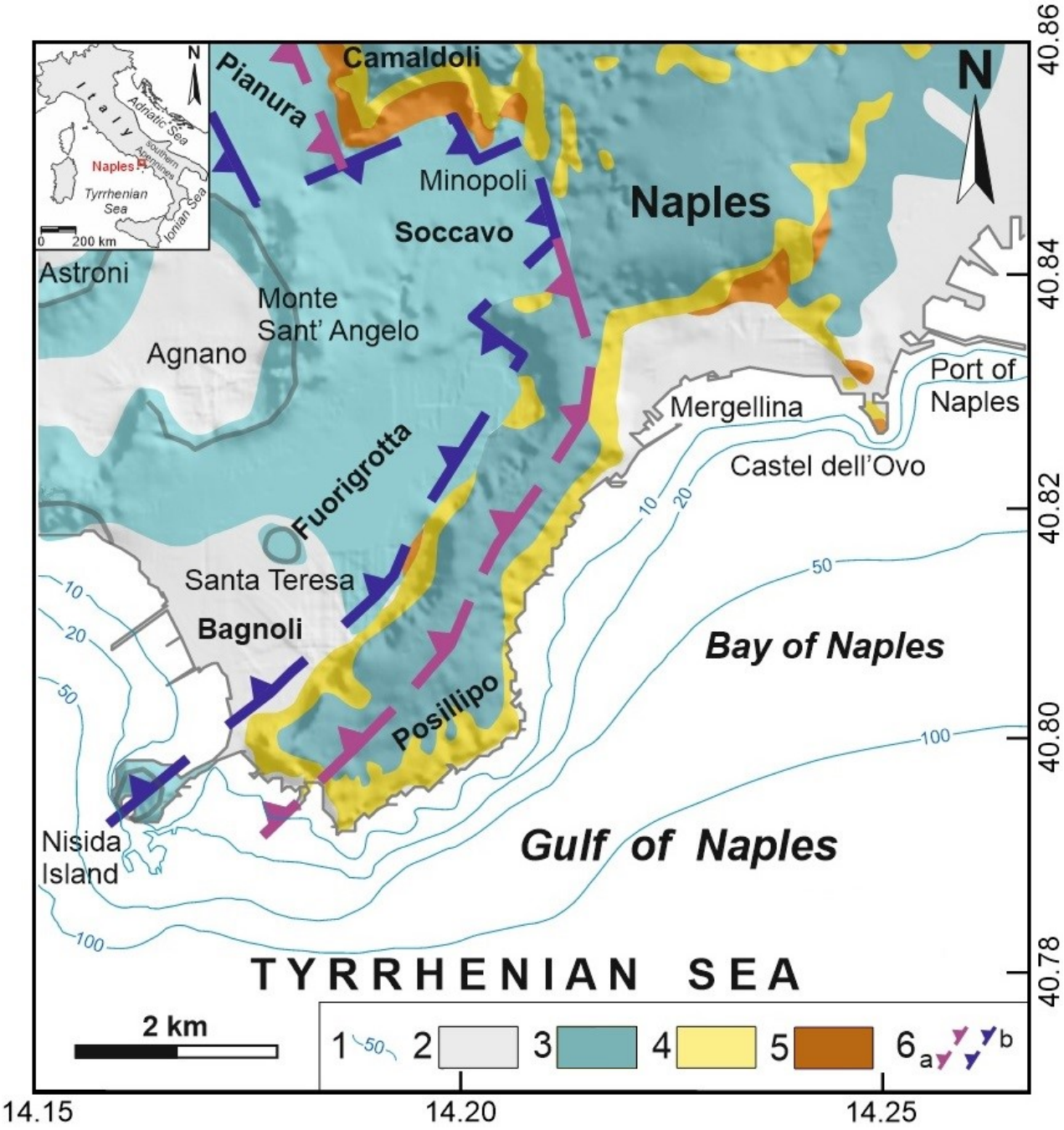

Figure 1: Geological map of the western coastland of Naples: 1, isobath (-m a.s.l.); 2, fluvial-marine, lagoon-marsh, dune-beach, and reworked pyroclastic deposits (Upper Pleistocene-Holocene); 3, Phlegraean Fields pyroclastic products (Quaternary); 4, Neapolitan Yellow Tuff (NYT, ~15 ka BP); 5, Campanian Ignimbrite (CI) and older volcanics (≥40 ka BP); 6, caldera rim: a, CI; b, NYT.

elements of the emerged and submerged coastland. The beaches are exposed to wind and waves coming from the I, II and III quadrant: the heaviest storm surges come from SE and SW.

Among the main environmental components that control genesis and development and characterize these sandy beaches, often dismantled or developed by storm surges and recent anthropogenic changes along the coast, there are climate, flora, and fauna.

Thermo-pluviometric data recorded in the period 1872-2006 by the Meteorological Observatory of the University of Naples Federico II classify the Mediterranean climate of Naples as subtropical, slightly continental, and humid-subhumid (Mazzarella 2007). According to the Köppen-Trewartha climatic formula, the climate is subtype Csa (Köppen 1936; Trewartha 1980; Kottek et al., 2006). In particular, the data of 2019 (Mazzarella et al., 2019) indicate for the period May-October 22-30 days with T_{max} > 20°C, 2-4 days with T_{min} ≤15°C and 2-13 days of rain, with the highest number of rainy days in February-March and October-November amounting to 908.3 mm/yr. These mild climatic conditions are very favorable to the use of urban beaches for about six consecutive months a year, between late spring and early autumn. The bioclimatic framework in the coastal zone favors the development of the ecosystem of Mediterranean maquis (Fig. 2), a composite association in which evergreen shrub and tree species with leathery leaves prevail.

The maquis results from anthropic interaction with the natural environment for millennia, therefore only rarely, where environmental conditions do not allow further plant evolution, can be considered spontaneous and depending on the primary maquis. Secondary maquis originates from degradation due to anthropic activity (*i.e.*, cuts, fires, agriculture, etc.) and more rarely from natural processes. The maquis would cover extensive stretches of the Neapolitan coastland, but intense anthropogenic changes currently sparse it. Urban beaches, used for seasonal bathing, do not allow the

Figure 2: Mediterranean maquis along the top of NYT sea cliff at Posillipo (photo C. Donadio 2013; W-E view).

colonization of any spontaneous vegetation, only some ephemeral psammophiles.

The steep tuffaceous sea cliffs with numerous coastal cavities and tafoni stimulated many birdlife species, protected by the EU Birds Directive since 1979, to frequent and nest in the urban area. Among the various birds that usually settle there are the herring gull (*Larus michahellis*), common swift (*Apus apus*), blue rock thrush (*Monticola solitarius*), white wagtail (*Motacilla alba*), some species of falcons as the peregrine (*Falco peregrinus*), kestrel (*Falco tinnunculus*), lesser kestrel (*Falco naumanni*, Fleischer 1818), the last considered a migratory species. The coast, especially in winter, is frequented by water birds such as the great cormorant (*Phalacrocorax carbo*), great crested grebe (*Podiceps cristatus*), sandwich tern (*Thalasseus sandvicensis*), and the colorful common kingfisher (*Alcedo atthis*), as well as by pelagic birds such as shearwaters (*Puffinus yelkouan*, *Calonectris diomedea*). About reptiles, mainly lizards (*Podarcis muralis*, *P. siculus*) and the Moorish gecko (*Tarentola mauritanica*) are present. Most of these animals share the coastal environment with humans.

On the beaches are abundant shells and bioclasts of mobile and rocky bottom organisms within 10 m of depth (Pérès & Picard, 1964), such as bivalve mollusks of Veneridae, Donacidae, Ostreidae, gastropods *Natica millepunctata*, *Nassarius mutabilis*, Muricidae, the uncommon *Aporrhais pespelecani* and the rare *Monoplex partenopaeum*. Numerous fragments of gastropods *Patella coerulea*, *Phorcus turbinatus*, *Haliotis tubercolata*, of bivalves *Mytilus galloprovincialis*, and *Arca noae*, of cirriped *Balanus improvisus* and Polychaeta from the submerged rocky substrate of sea cliffs and breakwaters, are widespread. The organogenic fraction composes a large part of the studied beach deposits, together with pyroclastic and lava minerals and debris, pumices, twigs, leaves and rhizomes of marine phanerogams, and allochthonous material (Fig. 3, 4, 5 and 6).

Case studies

The research focused on the study of six different urban beaches, selected among some thirty, in a stretch of 6 km of the western coast of Naples at the foot of the Posillipo hill, between Mergellina (NE) and Coroglio (SW). The beaches were surveyed, sampled, analyzed, and for the first time classified according to their geomorphological and environmental aspects in response to the degree of anthropization to which they are prone. From East to West, the studied environments are the Circolo Relax, Bagno Sirena, Spiaggia delle Monache, Spiaggia delle Telline, Cala della Zafferana, and Coroglio beaches (Fig. 3 and 4). The physiography of the coast summarizes in the following morphological elements, controlled by volcano-tectonics: a steep tuff sea cliff with a foot within -6 m of depth and a series of pocket beaches confined between short promontories. Structures which are best classified as artificial or induced by anthropic activity are coastal defenses, ports, and urban beaches. The morphology of the submerged landscape, at the foot of the active cliff, is characterized by low-sloping sandy-pebbly seabed extending down to about -15 m of depth. Here, the edge of a steep paleo-cliff covered by sand, whose base is at a depth of about -25 m, extends parallel to the current coastline (Monti et al., 2015).

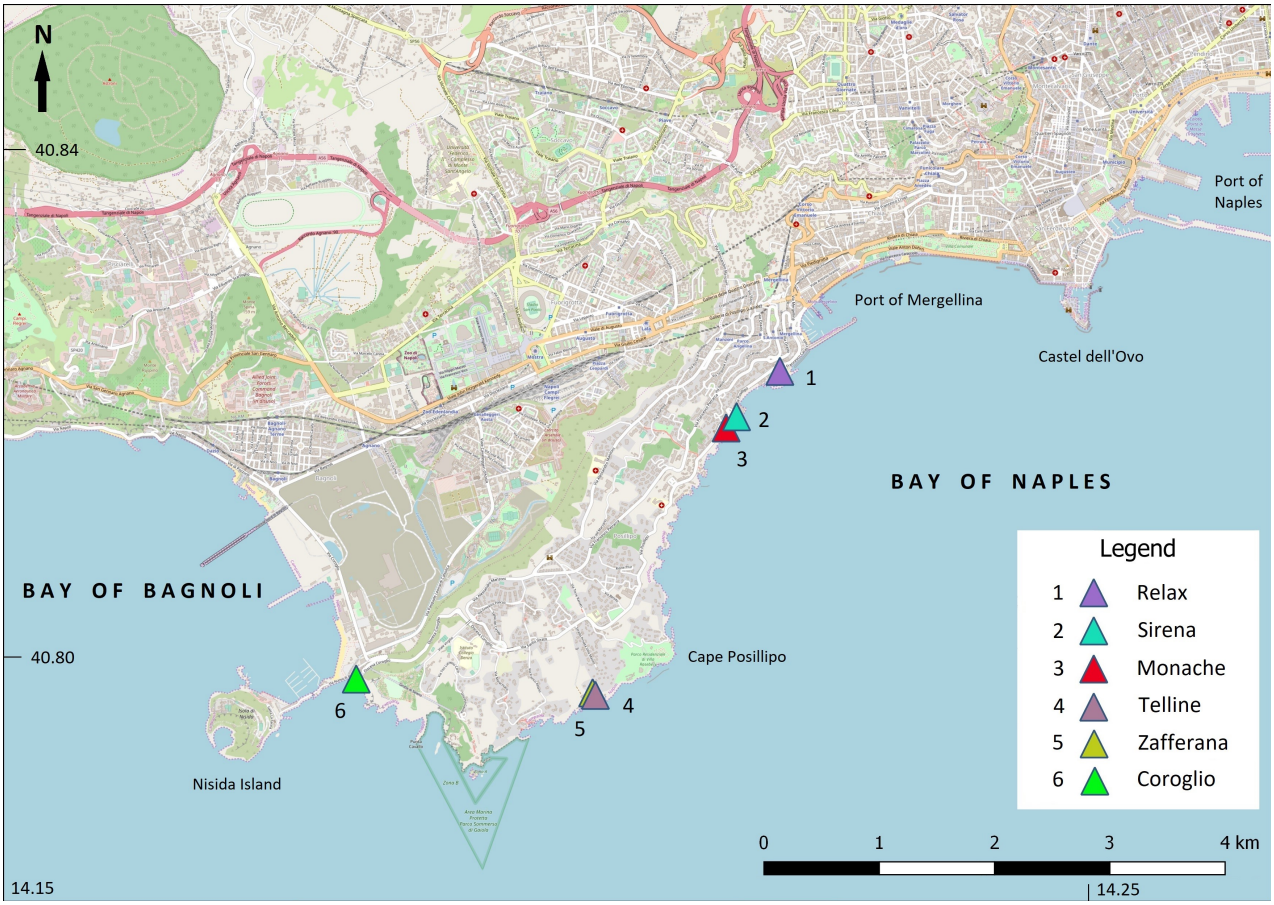

Figure 3: Location of the six studied urban beaches along the western coast of Naples.

Materials and Methods

Since autumn 2019 (Giovanzanti 2019; Sannino 2019; Delogu 2020), sediment samples were collected manually on six different beaches using a bailer. Samples were stored in a plastic bag with an alphanumeric code identifying the transept and transported in the laboratory for subsequent sedimentological analyzes. For each beach, two samples were collected, in total 12 samples, considering as a reference a benchmark in the backshore from which the emerged beach length was measured using a centimeter roll. The choice of sampling points is based on the geomorphological criterion, considering the storm berm or storm line and the shoreline. The sampling points were georeferenced in the WGS84 geographic coordinate system using a Garmin GPS II satellite radio receiver, the altitude (m asl) was obtained from the online GIS Google Earth Pro with which also the average gradient (%) was calculated. Finally, inclination and wave-exposure (°) of the beach were measured in the field with a Wilkie geologist's compass and clinometer.

Morphometry

To classify the beaches, morphometric parameters both through surveys carried out in the field and with Google Earth Pro tools were measured. In particular, the length (*L*), mouth of the bay (*C*), embayment (*E*), deepness of the bay (*Db*) are obtained: *L* is a curve, *C* the distance between the tips of topographic obstacles (promontories, breakwaters or both) bordering the beach, *Db* the orthogonal distance between *C* and the maximum curvature (concavity or

convexity) of the shoreline, and the *L/C* ratio describing the shore line morphology (1 < *L/C* < 1 is rectilinear, 1.15 < *L/C* <1.90, is arcuate as positive if concave or negative if convex, *L/C* > 1.90 is very arcuate).

Figure 4: The six studied beaches of Naples: a, Circolo Relax, inside a dock; b, Bagno Sirena, at the NYT sea cliff foot; c, Spiaggia delle Monache, between the anthropized tuff cliff and a breakwater; d, e: peri-urban beaches of Spiaggia delle Telline and Cala della Zafferana, respectively, two pocket beaches modeled in the NYT; f, Coroglio beach, at the NYT sea cliff foot (photos C.Donadio 2019, view: a, SE-NW; b, SW-NE; c, E-W; d, e, S-N; f, W-E).

Sedimentology and Morphoscopy

Samples were analyzed for classification, texture, grain sizes, and morphoscopic analysis of quartz and silicate grains (K-feldspars and Na-plagioclases), more resistant to wear as corrosion and corrasion. Particle size analysis was carried out following the standard technique of Folk and Ward (1957). After preparation and washing with distilled water, all the samples were dried in an oven at 80°C for 72 h, mechanically quartered, and weighed with a digital balance. Then samples were subjected to dry sieving through a series of stacked sieves, with 1/2 φ class intervals from 8000 up to 63 μm, in a Ro-Tap mechanical sieve shaker machine for 15 minutes. For each sample, classification, texture group, histograms and cumulative curves were plotted, and several moment statistics were calculated, in keeping with to the graphic method of Folk & Ward (1957), were calculated through the software Gradistat v.9.1 (Blott & Pye 2001): M_z, mean size; σ_I, sorting; S_{kI}, skewness; K_G, kurtosis.

The grain size fraction of 2 ϕ (250 μm) of the 12 samples was observed through an optical stereomicroscope Leica MZ16 to recognize morphoscopic features of sand quartz and silicate grains modeled in different genetic-depositional environments. In these granulometric fractions, 100 granules of quartz and silicate for each sample, in total 1200 grains, were selected and classified into three categories, according to Angelucci & Palmerini (1964): NA, not abraded, but transparent and angular; BT, translucent blunt, with subrounded to rounded edges; RO, well rounded opaque grains. The number of granules of each class is processed with the software Tri-Plot v.1.4

Figure 5: Sandy-pebble deposits, pumices, bioclasts, twigs, and allochthonous material of the Monache beach (photo M.R. Delogu 2019; SW-NE view).

(Graham & Midgley 2000) to obtain the percentages and the triangular diagram with the three-class (NA, BT, RO) at the vertices, showing the distribution as a function of the particle size of 2 φ (250 μm).

The rounding of the granule indicates the kind of wearing experienced during transport which varies with the distance, duration, intensity, mechanical strength of the type of rock, and particle size (Ricci Lucchi 1980). The presence of well-rounded granules in the sand would indicate a long staying on the beach and strong wear by the sea waves, while well-worn granules result from transport and erosion cycles (Ricci Lucchi, 1980). Generally, the transparent non-worn quartz and silicate grains (NA) come from cliffs or paleo-cliffs surrounding the shoreline: they have more defined, angular and serrated edges, instead translucent blunt (BT) granules show less angular edges as they are corroded from water and corraded by friction with the substrate. The transport agent of the latter is attributable to a stream or paleo-stream that deposited them at the mouth or in the sediment of a detrital-alluvial fan, then distributed along the littoral. Finally, rounded

Figure 6: Sandy-pebble sediments, lava and concrete boulders with bioclasts, twigs, litter, and plastics beached on the Coroglio littoral. In the background, Nisida Island (photo M.R. Delogu 2019; NE-SW view).

opaque granules (RO) are attributable to coastal dunes, as rounding and opacity produced by the morphoselective wind action and corrasion typical of these Mediterranean and subtropical environments (Valente 2012; Balassone et al., 2016; Pennetta et al., 2016; Donadio et al., 2018a, b; Souza et al., 2022).

Results

The morphometric parameters allow comparing the physiography, size, and orientation of the six urban beaches (Fig. 7). In particular, the length varies from less than 5 m of the Spiaggia delle Telline beach to over 120 m of Coroglio beach, the average gradient is ~0.05%. The particle size analysis provided information on the origin, mode of transport, and depositional conditions of the sediments. The littoral drift, due to the longshore currents, is influenced by the breakwaters which in the sheltered area form a calm water zone where clockwise and counterclockwise circulation cells is active. Here, sand with poor pelitic fraction is deposited, according to the limit of cutoff diameter (*LCD*) of 1.25 mm (0.5 φ) of beaches in the Mediterranean-type geomorphic system (Limber et al., 2008).

The sedimentary features of the beach samples are reported in Table 2. The deposits show unimodal or bimodal distribution with rather homogeneous grain size, are classified mostly as medium sand and subordinately as coarse to very coarse sand, poorly to moderately sorted, coarse skewed and leptokurtic. The cumulative frequency curves of the sediments grouped in the granulometric spindle show values of the average granule M_z distributed between -2 and 3 φ (Fig. 8).

The morphoscopic analysis highlighted a predominance of translucent blunt (BT) granules in the two main groups of genetic-depositional environments (Fig. 9).

Discussion

For the first time, through integrated environmental, morphometric, granulometric, and morphoscopic analyses, six urban beaches on the western coast of Naples were studied. The interpretation of results, to each other compared, allowed us to outline the main morphosedimentary features of these beaches, aiming for a modern morphotypological classification, also based on biotic and anthropogenic elements as well as the structural index I = 0.76 of the coasts (Vicinanza et al., 2008) equal to the ratio between the length of coastal defenses and that of littoral (Table 3).

Among the six beaches, two are natural and four of anthropic genesis, the latter showing a high degree of anthropization, such as bathing facilities, residential buildings, breakwaters, and port docks. The particle size analysis showed mainly medium

Table 2: Sedimentary characteristics and classification of beach deposits: RX, Circolo Relax, BS, Bagno Sirena, SM, Spiaggia delle Monache, ST, Spiaggia delle Telline, CZ, Cala della Zafferana, SC, Coroglio; Lat., Latitude, Lon., Longitude, M_z, grain mean size; σ, sorting; S_{kI}, skewness; K_G, kurtosis; NA, transparent not abraded, BT, translucent blunt, RO, rounded opaque quartz and silica grain shape. The coordinate system is WGS84, $\varphi = -\log_2 D_{mm}$, where D is the grain diameter in millimeters.

Sample	Lat.	Lon.	Heigh	Gravel	Sand	Classification	Mz	σ	SkI	K_G	Morphoscopy (%)		
#	(°)		(m asl)	(%)		(Folk & Ward, 1957)	φ				NA	BT	RO
RX1	40°49'22"	14°13'06"	0.0	2.7	97.3	Medium Sand	1,633	1,509	-0.405	1,112	25	70	5
RX2	40°49'21"	14°13'06"	0.3	7.4	92.6	Medium Sand	1,584	1,302	-0.511	1,393	35	63	2
BS1	40°49'09.5"	14°12'49.1"	0.0	0.4	99.6	Medium Sand	1,419	0.731	-0.003	1,050	30	65	5
BS2	40°49'10.2"	14°12'49.4"	0.3	0.6	99.4	Medium Sand	1,528	1,092	-0.207	0.798	35	63	2
SM1	40°49'06"	14°12'46"	0.0	0.6	99.4	Medium Sand	1,735	0.615	-0.138	1,153	36	62	2
SM2	40°49'06"	14°12'46"	0.4	0.4	99.6	Medium Sand	1,353	0.509	0.031	1,063	38	60	2
ST1	40°47'52.1"	14°11'57.9"	0.0	6.2	93.8	Coarse Sand	0.008	0.759	0.034	0.937	57	40	3
ST2	40°47'51.9"	14°11'57.8"	0.2	1	99	Coarse Sand	0.665	0.560	-0.105	1,005	62	35	3
CZ1	40°47'52.7"	14°11'56.9"	0.0	19.5	80.5	Very Coarse Sand	-0.538	0.594	-0.144	1,069	40	60	-
CZ2	40°47'52.6"	14°11'56.7"	0.3	18.1	81.9	Very Coarse Sand	-0.513	0.583	0.088	1,005	35	65	-
SC1	40°47'56.7"	14°10'29.1"	0.0	-	100	Medium Sand	1,778	0.617	-0.133	1,042	32	65	3
SC2	40°47'56.4"	14°10'29.2"	0.5	0.5	99.5	Coarse Sand	0.780	0.575	0.019	1,111	31	66	3

sediments tending to coarse, with abundant bioclasts of bivalve mollusks, gastropods, and polychaetes. Three main granulometric facies were identified, *i.e.*, medium, coarse, and very coarse sand, whose dimensions mostly fall between -1.5 and 3 φ. A light decrease in the mean grain size of sand is registered from the Northeast to Southwest beach.

The color, determined through the Munsell Soil Color Chart (Cooper 1929), refers to dry beach deposit and varies from gray (6YR6/1) to dark gray (4YR4/1), sometimes with a very pale brown hue (2.5Y8/2) due to the NYT sea cliff .

The beach of Circolo Relax is a port beach. Therefore, it does not have a natural appearance and is bordered by buildings (Fig. 4a, 7a). A port beach is generally small, sandy, with allochthonous material, *i.e.*, clay and landfill material, plastics, cigarette filters, and sparse psammophilous flora as well as planted or semi-natural species such as *Crithmum maritimum* and *Capparis spinosa*. Bagno Sirena and Spiaggia delle Monache beaches (Fig. 4b,c and 7b,c), under private concession the first and public the second one, are contiguous. Both developed to the back of coastal defenses: the first one, back to a short, emerged, parallel and detached from the shoreline breakwater in whitish carbonate boulders, while the second one, back to a long, emerged, parallel and adjacent to the shoreline breakwater in dark

L/C					
a	b	c	d	e	f
-0.70	0.82	3.38	0.27	1.05	0.28

Figure 7: Morphometric parameters of the six urban beaches (after Google Earth Pro 2023): a, Circolo Relax, b, Bagno Sirena, c, Spiaggia delle Monache, d, Spiaggia delle Telline, e, Cala della Zafferana, f, Coroglio. L, length, C, mouth of the bay, E, embayment, and L/C ratio for the shore line shape.

gray lava boulder, once detached from the coast and gradually filled by sediments. Spiaggia delle Telline and Cala della Zafferana (Fig. 4d,e and 7d,e) are small sandy pocket beaches modeled into the NYT, the first one is the smallest measuring less than 5 m of length, without coastal defenses. Finally, the beach of Coroglio (Fig. 4f, 7f) is intermediate between a pocket beach and a beach at the tuffaceous sea cliff foot, mainly sandy with autochthonous and allochthonous coarse clasts, bordered by a tuff promontory to the East and a long, adjacent and emerged breakwater in whitish carbonate boulders to the West. In this beach, frequentation and sea bath are forbidden due to pollution and rockfall hazard.

The actions and strategies dictated by specific interests in the mentioned areas turn out to be often in conflict but also exemplify the composite articulation of the observed phenomena. This is mainly because of a failure to integrate idiosyncratic governance decisions taken by a large number of actors:

4 summarizes the multi-scalar critical situation.

The mismanagement given by the "hyperterritorialization" of competencies and the multiplication of interests exacerbates the weakening of shorelines from a structural point of view and increases the exposure of the resident population to risks of various natures. This interaction results in an evident socio-spatial injustice that impairs the effective enjoyment of fundamental rights (Guadagno & Grasso, 2022).

In conclusion, comparing the results obtained from field surveys and laboratory analyzes carried out on the six urban beaches (Tables 2 and 3; Fig. 7, 8 and 9), it follows that two are of natural and four of anthropic genesis. All have a medium-fine to coarse grain size, and the granules in the

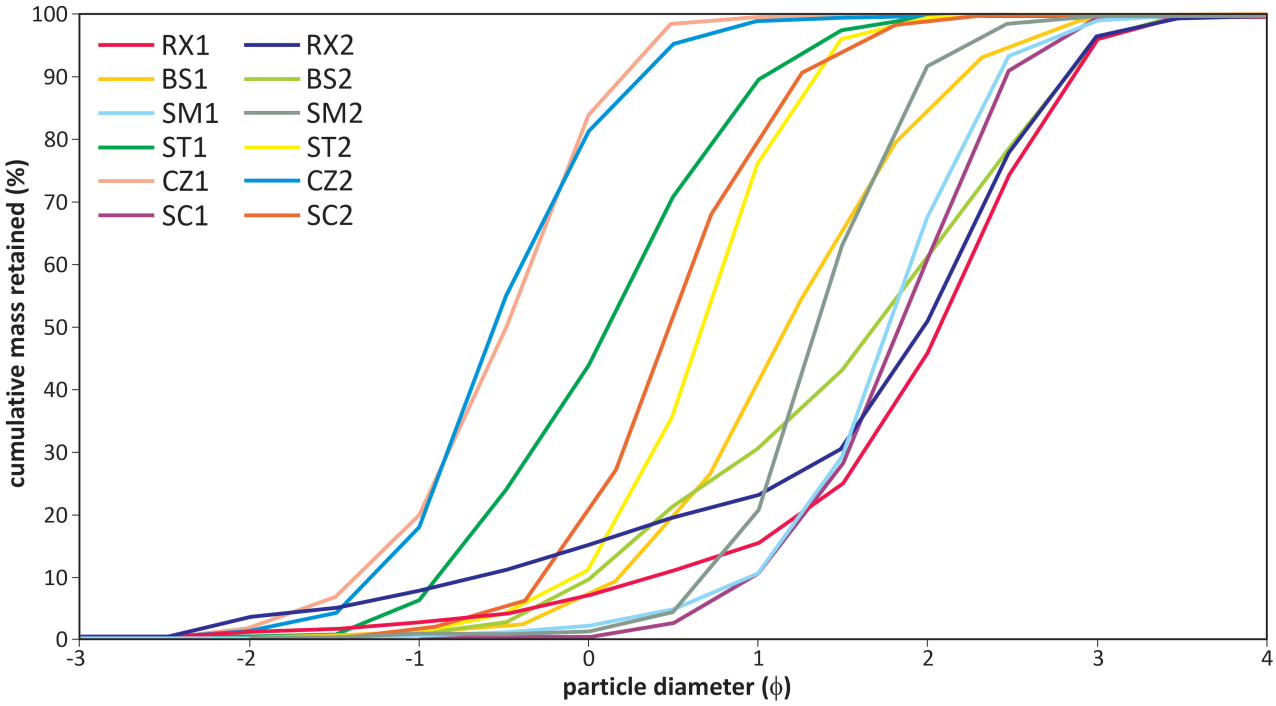

Figure 8: Granulometric spindle of the cumulative frequency curves of the two samples collected in each of the six urban beaches, along the storm berm or storm line (1) and the shoreline (2): RX, Circolo Relax; BS, Bagno Sirena; SM, Spiaggia delle Monache; ST, Spiaggia delle Telline; CZ, Cala della Zafferana; SC, Coroglio.

Table 3: Morphotypological classification of the six urban beaches of Naples, from NE to SW, based on different factors: morphometric and morphosedimentary features, granulometric classification according to Folk & Ward (1957), morphoscopy (Angelucci & Palmerini 1964; Pennetta et al., 2016; Arienzo et al., 2020) which indicates the prevailing shape class of granule, color referring to dry beach deposit through the Munsell Soil Color Charts (Cooper 1929), and anthropization which considers the degree of littoral consumption due to coastal defenses, structures and infrastructures on the emerged beach and its carrying capacity (Vicinanza et al., 2008; Carboni & Russino 2013). The arrow indicates the geographic sequence of the beaches.

	Beach	Genesis	Granulometry	Morphoscopy	Color	Anthropization	Classification
NE ↓ SW	Circolo Relax	Anthropic	Medium sand	ST	Gray	High	Port beach
	Bagno Sirena						Breakwater beach
	Spiaggia delle Monache						
	Spiaggia delle Telline	Natural	Coarse sand	NA		Nil	Pocket beach
	Cala della Zafferana		Very coarse sand	ST		Low	
	Coroglio	Anthropic	Medium to coarse sand		Dark Gray	High	

highest percentage are the translucent blunt ones (BT, 60-65%), probably linked to repeated cycles of corrasion in a sheltered and calm water environment, followed by the transparent not abraded ones (NA, 35-40%). The very low percentage of rounded opaque (RO, 3%) granules suggests the presence of paleodunes in neighboring areas not far away (Valente 1999; De Pippo et al., 2002b), both in the NW (Bagnoli-Fuorigrotta Plain) and SE (Riviera di Chiaia), as currently there are no coastal dunes to the back of these small urban beaches.

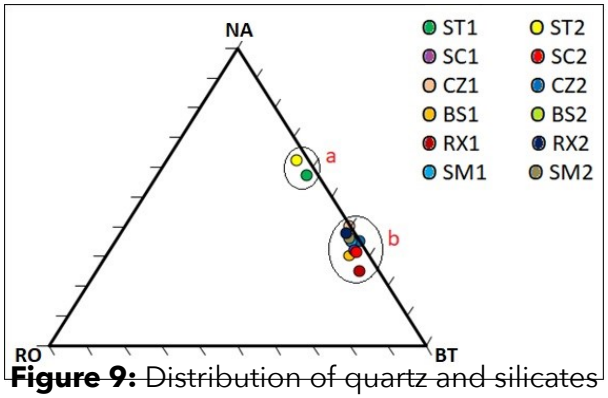

Figure 9: Distribution of quartz and silicates grains of 250 µm resulting from the morphoscopic analysis: NA, transparent not abraded; BT, translucent blunt; RO, rounded opaque. The grains are grouped in two main fields, with a prevalence of ST (b) on NA (a). RX, Circolo Relax; BS, Bagno Sirena; SM, Spiaggia delle Monache; ST, Spiaggia delle Telline; CZ, Cala della Zafferana; SC, Coroglio urban beaches.

The beaches differ in the degree of anthropization: the Circolo Relax beach has a higher degree than the others, both as is a port beach used for bathing and the presence of allochthonous material transported by the sea, often of anthropic genesis, also due to misbehavior by beach users as in other cases. Unlike the other urban beaches, its shoreline is convex (*L/C* = -0.7; Fig. 7) for sediment accumulation and, due to its strong anthropic genesis, this beach has only sparse psammophilous vegetation in the backshore.

The Bagno Sirena beach once was in a small open bay, now its current degree of anthropization is attributable to the presence

offshore of a breakwater in boulders parallel to the shore, a licensed beach facility, a jetty at sea until 2019, a bar and a restaurant. The constant frequentation of the beach and the mechanical tools used for its maintenance, especially after the autumn-winter period or intense sea storms, rework the sediments eroded by the surface of the nearby tuff cliff, transported by waves and sea currents, partially limiting their accumulation.

The Spiaggia delle Monache, on the other hand, a very arcuate beach (*L*/*C* = 3.38; Fig. 7), is into a closed bay with a lower degree of anthropization than the other two, attributable mostly to a barrier adhering to the shore and bathing as it is one of the few free beaches managed by the Municipality. These, in addition to their natural conditions, are subject to strong human pressure linked to the intense tourist development which is putting their conservation at risk.

The Spiaggia delle Telline and Cala della Zafferana are two natural pocket beaches, superimposed on a paleo stream, of different dimensions but same morphodynamics, with some surfaced and submerged Roman ruins excavated in the NYT.

Finally, Coroglio beach is an intermediate type between a previous narrow beach at the sea cliff foot transformed in pocket beach after the construction of a long breakwater from the coast to the Nisida Island, to protect the road.

This proposed classification of the Naples urban beaches (Table 3) integrates existing ones based on physical and quantitative elements (Table 1; Valente 1999). Urban beaches are ephemeral environments that may rapidly form or disappear due to erosion, transport and deposition processes. They often represent a buffer between the wave action and the inactive cliff behind, with structures and infrastructures, protecting it from undermining. Their complex management depends also on several stakeholders (Table 4), from central to local ones (Donadio & Guadagno, in press).

In this regard, it would also be necessary to evaluate the beaches anthropic carrying capacity (Carboni & Russino 2013). This is a key element toward an effective management of the number of bathers that each place can support without compromising its environmental features, including the immediately adjacent areas (*e.g.*, sensitive natural habitats).

Due to their tourist-recreational importance and for the protection of the cliff, beaches should be preserved through correct management. Appropriate policies are the

Table 4: Mosaic composition of stakeholders' skills and interests for the Neapolitan coast, often juxtaposed without integrating.

Campania Region	**Metropolitan City of Naples**	**City of Naples**	**Local municipalities**	**Linear infrastructure managers**	**Coast Guard**
Hydrographic District of the Southern Apennines	**Naples Port Authority**		**Cultural heritage protection organizations, including UNESCO, and Marine Protected Areas**	**Marine Protected Area "Gaiola Underwater Park"**	
Operators and managers of beaches			**Environmental associations (*e.g.*, Legambiente)**	**Movements for public beaches (*e.g.*, Mare Libero e Gratuito Napoli)**	

removal with sustainable techniques of pollutants as clay material, macroplastics, microplastics, and microfibers transported by the littoral drift of sediments, waves and sea currents, and wind, but above all attributable to incorrect user behavior (Jambeck et al., 2015; Choy et al., 2020; Arienzo & Donadio 2023). Together with the morphosedimentary features, the environmental design and ecological aspect must also be considered, to safeguard the habitat and biodiversity of these highly vulnerable urban environments.

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The Neapolitan contribution to the scientific studies on *Cannabis*. A historical overview

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Abstract

After a look at the history of scientific studies of *Cannabis* in Europe and Italy, in its two forms of fiber hemp (*C. sativa*) and psychoactive hemp (*C. indica*), this article traces the history of the medical, botanical and agronomic studies undertaken in Naples starting from the mid-19th century. Two main historical periods stand out. A first phase, mainly in the 70s and 80s of the 19th Century, involved medical studies with Indian hemp which involved prominent figures of the Neapolitan culture, including Sebastiano De Luca, Eugenio Fazio, Paolo Panceri, Mariano Semmola. Raffaele Valieri's clinical research undertaken at the Incurabili Hospital stands out for its originality; his studies on the therapeutic properties of sativa hemp can be considered the most extensive and detailed not only in Italy but in Europe. A second phase, dated to the 1930s, saw the first Italian cultivations of Indian hemp by Biagio Longo at the Experimental Station for Officinal Plants of the Botanical Garden of Naples. In 1931 Longo gave rise to the "Calcutta strain", which was kept active throughout the 20th century with annual cultivations and became the primary reference sample in scientific research carried out in Italy on Indian hemp.

Keywords: Cannabis, Raffaele Valieri, Biagio Longo, Botanical Garden of Naples

Riassunto

"Il contributo napoletano agli studi scientifici sulla *Cannabis*. Una rivisitazione storica". Dopo uno sguardo sulla storia degli studi

scientifici della *Cannabis* in Europa e in Italia, nelle sue due forme di canapa da fibra (*C. sativa*) e canapa psicoattiva (*C. indica*), il presente articolo ripercorre la storia degli studi medici, botanici e agronomici intrapresi a Napoli a partire dalla metà del XIX secolo. Si evidenziano due principali periodi storici. Una prima fase, principalmente nei decenni '70-'80 del XIX secolo, riguardò studi medici con la canapa indiana che videro coinvolti personaggi di spicco della cultura partenopea, fra cui Sebastiano De Luca, Eugenio Fazio, Paolo Panceri, Mariano Semmola. Risaltano per originalità le ricerche cliniche di Raffaele Valieri intraprese presso l'Ospedale degli Incurabili; i suoi studi sulle proprietà terapeutiche della canapa sativa possono essere considerati i più estesi ed articolati non solo d'Italia ma d'Europa. Una seconda fase, datata agli anni '30 del XX secolo, vide le prime coltivazioni italiane della canapa indiana per opera di Biagio Longo presso la Stazione Sperimentale per le Piante Officinali dell'Orto Botanico di Napoli. Nel 1931 Longo diede origine al "ceppo di Calcutta", che per tutto il XX secolo fu mantenuto attivo con coltivazioni annuali e divenne il campione di riferimento primario nelle ricerche scientifiche svolte in Italia sulla canapa indiana.

Parole chiave: Cannabis, Raffaele Valieri, Biagio Longo, Orto Botanico di Napoli

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Introduction

Hemp is a dioecious plant recognized in botanical taxonomy as *Cannabis sativa* L., belonging to the *Cannabaceae* family. For over two centuries the problem of the difference between fiber hemp and hemp with psychoactive properties has caused a lot of ink to flow, also for its utilitarian, social and legal implications. At a botanical level, this differentiation gave rise to a long diatribe concerning the problem of speciation of the *Cannabis* genus, focused on the recognition of only one, or two or three species within this genus (Small 1979); a diatribe that originated towards the end of the 18th century, when French botanist Jean-Baptiste Lamarck recognized psychoactive hemp as a separate species, which he called *C. indica* (Lamarck 1783, I, p.695).

Without delving further into the problem of speciation of the *Cannabis* genus, —which is now considered as monospecific, *C. sativa* being the only acknowledged species (Ren et al., 2021) – for the historical examination of the present study it is sufficient to observe how for the entire nineteenth century and a good part of the twentieth century, botanists and doctors clearly distinguished local hemp, which had been cultivated for centuries to make fabrics and ropes, from that which was imported from the East mainly in the form of *haschisch*, the resin obtained from the flowering tops of the female plant and whose name was transcribed also as *ascisc*, *haschich* or *hatschisch*. For convenience of discussion, in this writing the two varieties will be distinguished with the old terms *sativa hemp* and *Indian hemp*.

In Italy the popular names given to sativa hemp vary from region to region. In northern Italy the variants *canape*, *càneva*, *canava*, *canva* prevail, and in the Po Valley also *canapuccia* and *canapone*; in southern Italy the variants *cànnavo* (Naples), *cànnavu* (Calabria), *cannavusa*, *cànnavu* (Sicily), *cànnau*, *cagnu* (Sardinia) prevail (Penzig, 1924, I, pp. 91-92). In some cases, the female plants were distinguished with a different name from the male ones. For example, in Romagna the male plants were called *canva*, while the female ones *canavón* (Pieri 1998, p. 133).

Hemp in Europe

Regarding the center of origin of the *Cannabis* genus, there is a certain unanimity among scholars to locate it in Asia, and according to the most modern studies in East Asia (Ren et al., 2021).

Numerous archaeobotanical data have highlighted how hemp had arrived in Europe long before man began to cultivate it, and this to the detriment of the hypothesis still in vogue that this plant had been imported in later periods from Asia into Europe by of man (see for example Dörfler, 1990). The oldest data known so far on the presence of hemp in Europe date back to the beginning of the Holocene and came to light in Italy. Among these, the presence of hemp pollen in environmental core samples carried out in Lake Albano (Rome), with a dating of 11,500 BCE, should be mentioned (Mercuri et al., 2002), and in Lake Grande of Monticchio (Potenza), dating back to 9000 BCE (Huntley et al., 1996; for a review of archaeobotanical data see Samorini, 2019).

As regards sativa hemp, its cultivation in Italy is attested since the Roman period. Archaeological data have shown an increase in the environmental presence of hemp pollen in the Lazio region starting from the 2nd century BCE, and this would have been caused by the cultivation of the plant (Mercuri et al., 2002). Pliny the Elder, who wrote in the 1st century CE, seems to have been the first classical author to report on local cultivations, stating that "*as regards size, that of Rosea in the Sabine region reaches the height of the trees*" ("*quod ad proceritatem quidem attinet, Rosea agri Sabini arborum altitudinem aequat*"; Pliny, *Hist.Nat.*, XIX, p.174). The ancient Sabines occupied a region of the Central Apennines corresponding to the current provinces of Rieti and part of L'Aquila.

After the fall of the Western Roman empire, the cultivation of sativa hemp spread to various Italian regions, although for a long time it mostly concerned small productions to satisfy the local need for fabrics and ropes. A first notable large-scale production was achieved in Sicily starting from the 9th century CE, during the Arab domination (Andreolli, 2005). But it was only starting from the 18th century that hemp production in Italy established itself as one of the most important realities at an international level, with the most productive areas located in Emilia-Romagna, Campania (Caserta and Naples) and Piedmont (Roletto,1923).

The knowledge and presence of psychoactive hemp (indica) in Europe in ancient and medieval times appears more problematic. In classical Greco-Roman literature, with the exception of a well-known passage by Herodotus on a curious Scythian ritual, the interpretation of which remains questionable (Samorini, 2018, pp. 12-13), there is a disconcerting silence on the intoxicating properties of hemp. Both Greek (Pausanias, Athenaeus, Dioscorides, Galen) and Latin authors (Pliny, Columella, Oribasius), while showing knowledge of hemp, seem to be unaware of its intoxicating potential. All that remains to be deduced is that Greeks and Romans did not know about intoxicating hemp, as suggested by Brunner (1977). Similar to classical texts, Renaissance herbals also ignore the intoxicating properties of hemp, and the distinctions they sometimes make between "domestic hemp" and "wild hemp", as well as between "male" and "female" hemp, not they correspond neither to the two forms now recognized as *sativa* and *indica*, nor to the two dioecious forms (Samorini, 2019, pp. 86-88).

Among enigmas and large gaps, the impression arises that a history of Indian hemp in ancient and medieval European times has yet to be written. However, despite all the surprises that this history could reserve, the knowledge, or the presence and use of this plant and its derivatives during the long medieval period, seems to have been limited to certain geographical and socio-cultural areas. It was only with the French military intervention in Egypt, during the Napoleonic wars, that the knowledge and use of psychoactive hemp spread in Europe, through the two tracks of medical environments and those of the intellectual, artistic and literary avant-garde currents that crossed in those times the European nations. First of all, the French; their main antagonists, the English, followed closely behind them. It didn't take many years to see the "new" exotic drug spread to Spain and Portugal, Holland and Germany.

In nineteenth-century European literature, the first writing that dealt with the effects of Indian hemp appears to be the 1809 article by the Frenchman Silvestre de Sacy (1809), who analyzed the legend of the "Old Man of the Mountain" and the Islamic sect of the Ishmaelites, known in Europe as "Assassins", promoting the etymological interpretation of this term as deriving from "haschisch"; an etymology that prevailed throughout the 20th century but which current studies consider incorrect (Guba, 2016).

The first Western medical study on Indian hemp was performed by the Irishman William Brooke O'Shaughnessy (1809-1889). He resided for several years in India, where he had the opportunity to observe the traditional therapeutic use of *Cannabis* and studied new applications. His major paper on Indian hemp, published in a Bengali journal, and some years later in a London medical journal (O'Shaughnessy, 1840; 1843), promoted

Western medical interest in this plant, and was reviewed in medical journals from all over Europe, including Italy. It is interesting to note how the Italian review of this writing referred to its first Bengali edition (Redazione, 1840), demonstrating the attention and potential for international observation on the part of Italian doctors. This same review from 1840 would appear to be the first modern Italian writing on Indian hemp.

The best known of the scientific writings of the first half of the nineteenth century is the book by Jacques Moreau de Tours, *De l'haschisch et de l'aliénation mental*, dated 1845. In the same periods, the *hashisch* left the strictly world of Parisian doctors and was promptly seized by that group of intellectuals and men of letters known as "cursed poets", who for the occasion had created a *Club des Haschischins*, which held its meetings in a hotel on the Île-de-France, the islet of the Seine located in the heart of old Paris. Several of these writers have left us descriptive and poetic works on their experiences with *hashish*; it is enough here to recall *The Hashish Eaters' Club* by Théophile Gautier (1846) and *The Artificial Paradises* by Charles Baudelaire (1860)

Indian hemp in Italy

As regards Italy, for the ancient and medieval periods it cannot be excluded that Indian hemp was occasionally known among Italian populations, and that on more than one occasion it may have been present in pharmacies if not in the gardens of medieval monasteries. However, it is quite indicative of its rarity that this plant is ignored by the *Regimen sanitatis Salernitanum* of the 12th-13th century. This writing produced by the School of Salerno was destined to become one of the best-known medical works in the medieval Western world.

For modern times, research I carried out almost 30 years ago (Samorini, 1996) has highlighted a history of interest in *Cannabis* that reaches and aligns with the periods relating to other European nations. In the current state of this historical research, the date of the first reference to Indian hemp in nineteenth-century Italian literature reaches 1840, that of the first reference to its presence in Italian territory is 1845, and 1847 is the year of the first Italian experience with this plant reported in the literature (Samorini, 2018). These origins were known to Italian authors who became interested in Indian hemp in the nineteenth century, but towards the end of the century and the beginning of the twentieth century, for reasons that remain to be clarified, this knowledge was lost.

In the same way as in other European nations, in Italy Indian hemp was initially the object of attention by the medical profession, due to the medicinal properties acclaimed by the international medical literature of those years, and promptly reviewed in the Italian medical journals. It was doctors who imported the first quantities of dried flower buds and *hashish* and marketed them in pharmacies.

Nineteenth-century doctors personally experimented with Indian hemp, almost always in oral intake, and later tried it on their patients suffering from the most disparate illnesses, both physical and mental; experiments that were not always crowned with success. Yet, for various

diseases, Indian hemp showed that it really possessed those "miraculous" properties so much acclaimed, to the point of giving rise to a real trend of interest and medical studies for hemp, in no way secondary to the general interest doctor in the rest of Europe towards this plant.

Reading the accounts of personal experiences left to us by these doctors reveals, in addition to impeccable professional goals, always highlighted by the same doctors, also a certain curiosity for the *fantasia* (phantasy) produced by the plant. The term *fantasia* was used in Italian medical literature to describe the visionary state induced by *Cannabis*, and Moreau de Tours (1845, pp. 3-4) refers that this Italian term was used also in the Levant. It must be considered that, throughout the nineteenth century, doctors were in the habit of testing each new batch of a drug on themselves before prescribing it to patients, and that many of the doctors involved in the origins of Italian relationship with Indian hemp had already known the effects of opium and its derivatives. When, towards the end of the 1850s, coca arrived in Italy, thanks to the hygienist Paolo Mantegazza, there was no doctor who recoiled from the possibility of experiencing its effects (Samorini, 1995). Moreover, all the doctors who were interested in hemp had read Moreau de Tours' text, where from the first pages this French doctor emphasised the importance of personal experimentation for scientific purposes (Moreau de Tours 1845, pp. 3-4).

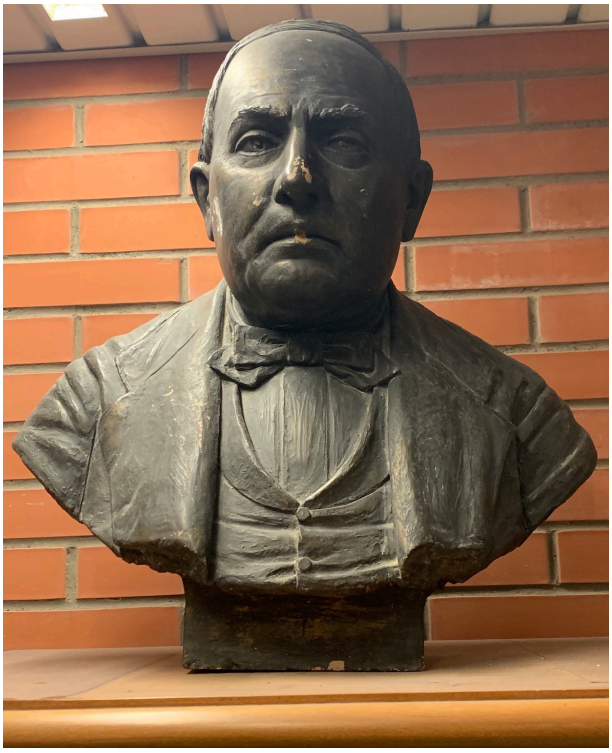

Figure 1: Sebastiano De Luca (1820-1880). Bust preserved in the Library of the Department of Chemistry of the Federico II University of Naples (photo by the author).

Most if not all psychoactive substances have medicinal properties, and it is no wonder that the role of the medical profession in the spread of these substances in Western societies has always been significant. In Italy and as regards *Cannabis*, its role was fundamental, as it was, a few decades later, in the case of cocaine.

Milan was the site of the first personal and clinical experiences with Indian hemp, and the most famous doctors of that period were involved: Andrea Verga, Carlo Erba, Filippo Lussana, Giovanni Polli. From the point of view of the historical-political context, we are at the time of the Risorgimento wars of independence, in which the Milanese population was directly involved on several occasions.

That the Milanese medical environment had been taking an interest in *Cannabis* for some years is demonstrated by the reviews and some articles that appeared in the 1840s in the *Gazzetta Medica of Milan*, at the time directed by B. Panizza and A. Bertani, in the *Annali Universali di Medicina* and on the *Annali di Chimica Applicata alla Medicina*, of

which Giovanni Polli was then director; magazines all published in Milan.

Giovanni Polli (1815-1880) was the first Italian experimenter with Indian hemp, and for over thirty years he was interested in *Cannabis*, experimenting with it on himself on different occasions and as a medicine in the treatment of various diseases, and reported the accounts of these experiences in those Annals of which he was director. In the same magazine he also published reports of experiences with hashish carried out by other doctors, reporting numerous news relating to the therapeutic use of *Cannabis* from other European nations and America (Samorini, 2018).

The Neapolitan studies

A second important focus of interest in hemp developed in Naples, and in two main historical periods: a first phase, in the 70s and 80s of the 19th century, concerned medical studies that revolved around the Incurabili Hospital. A second phase, dated to the 1930s, saw the first Italian cultivations of Indian hemp at the Orto Botanico of Naples.

The Neapolitan cultural environment's first contact with Indian hemp occurred abroad and saw as its protagonist a person destined to become a prominent scientist: Sebastiano De Luca (1820-1880) (Fig. 1). Of Calabrian origins, De Luca studied natural sciences and chemistry in Naples. He actively participated in the uprisings of 1848 and was sentenced to 25 years in prison. However, he managed to escape to Paris, where he continued to cultivate his interests in chemistry. Returning to Italy in 1857, he held the chair of chemistry at the University of Pisa until 1862, the year in which he returned to Naples and became the first professor of chemistry at the University of Naples. He published around 200 scientific articles, mainly on organic, inorganic, agricultural and industrial chemistry (Colella, 2016).

During his Parisian phase, in the spring of 1854, De Luca did not miss the opportunity to experiment with *hashish*, taking advantage of the generosity of a friend who had brought a certain quantity of the drug from the East. He took *hashish* orally in the form of a sweetish paste in the amount of 2-3 g and experienced the visionary effects for about four hours. De Luca found particularly interesting that under the effect of *hashish* forgotten things come back to mind, one had clear ideas, and the changes in sensations were so extraordinary, "*that they deserve to be carefully studied by conscientious experimenters*". The report of his experience was published in French in the journal of the Paris Academy of Sciences (De Luca, 1862a), and De Luca took care to have an Italian translation published in a couple of Neapolitan scientific journals as well (De Luca, 1862b; 1865). It was mainly these publications written in Italian by De Luca that aroused curiosity about Indian hemp among scientists living in Naples.

The hygienist doctor Eugenio Fazio mentioned in one of his writings that he had received Indian hemp from Paolo Panceri, who had obtained it during a trip to Egypt. Paolo Panceri (1833-1877) (Fig. 2) was of Milanese origins and graduated in medicine in Pavia, but his interests in natural sciences and anatomy led him to hold in 1861 the position of professor of Comparative Anatomy at the University of Naples and Director of its Zoological Museum (Del Giudice, 1878; Borrelli, 2023). In 1874 he made a long journey to Egypt, and it was on this occasion that on his return he brought with him a certain quantity of Indian hemp.

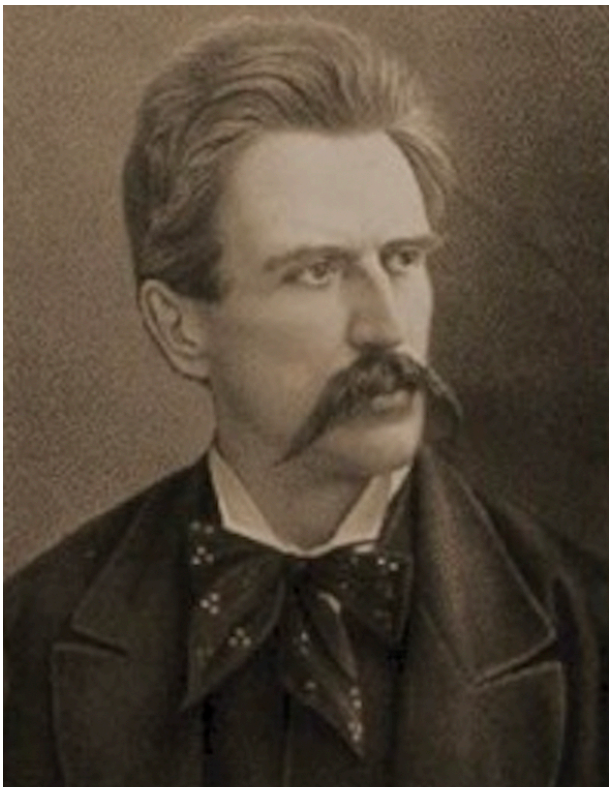

Figure 2: Paolo Panceri (1833-1877) (from Cornalia, 1877).

Eugenio Fazio (1849-1902), of Molise origins, carried out his profession in Naples. He is known for having written the first Italian hygiene treatise and for having founded and directed the *Rivista Internazionale d'Igiene* published in Naples. Fazio also wrote another book, *L'ubriachezza e le sue forme* ("Drunkenness and its forms"), which won the Cagnola prize from the Lombard Institute of Sciences and Letters in Milan (Testa, 2010). It was in this text that Fazio mentioned the intention of carrying out experiments with the Indian hemp received from Panceri: "*We hope before long to make a contribution to the study of the topic* (..) *The experiments instituted so far have not warned us of relevant innovations, except for the subjective modality*" ("*Speriamo da qui a non molto portare anche noi un contributo allo studio dell'argomento (..) Gli esperimenti istituiti finora non ci hanno avvisato di novità rilevanti, tranne delle modalità subbiettive*"; Fazio, 1875, p. 390). From these words it would be deduced that Fazio personally experimented with Indian hemp, but we do not know if he carried out the medical research that he intended to develop and if he left documentation of it in some of his writings which had not yet been identified.

Panceri also donated some *hashish* to two doctors who worked in Naples, Luigi Calabrese and Gennaro Fabiani, who used it for experiments on humans. They reported the results in an article that could be defined as "ghost", since it was included in a Neapolitan medical journal called *Il Cirillo* of which only one issue was published in 1878, and because none of the Neapolitan and more generally Italian authors who subsequently wrote on hemp shows knowledge of this writing. I learned of its existence while leafing through a bibliographic book on US military medicine (Merrill, 1898). Despite having been published in Naples, the only issue of the magazine *Il Cirillo* (not to be confused with several other magazines with the same title) is unobtainable in Neapolitan libraries, and it was thanks to the interest of Mauro Moreno of the Department of Agriculture of the University of Naples Federico II that a copy has been identified –perhaps the only example present in Italy– at the Central University Library of Bologna.

In their paper, Calabrese and Fabiani first mentioned some experiments with *haschisch* that Panceri himself had carried out in preliminary form before his premature death. He had orally administered half a gram to a dog, in which the phenomena of "drunkenness" were evident, and later 200 mg to a medical student, a dosage that did

not cause intoxication. Then the two doctors described their experiments on humans. They first tried smoking 250 mg and then 500 mg of *hashish* mixed with tobacco, without success. They later administered 300 mg orally to a volunteer, a 28-year-old "cultured and intelligent, robust" young man. This time the intoxication manifested in an impressive manner and lasted for over 4 hours. The subject's visionary state reached such intense and eventful moments that the two doctors struggled to carry out physiological measurements, including variations in body temperature and heart rate. They concluded that, in addition to being a stimulant of brain functions, *hashish* is also a stimulant of the sympathetic system (Calabrese & Fabiani 1878).

In 1887, a long dissertation by the psychiatrist Bruno Battaglia, who for several years directed a mental hospital in Cairo, Egypt, appeared in a Neapolitan psychiatric journal (*La Psichiatria, la Neuropatologia e le Scienze Affini*). He described the effects of *hashish* on humans with an essentially psychiatric approach, based on personal clinical case studies and careful observation of the customs of the Egyptian population. Although it concerns the uses and effects of hemp in a foreign country, Battaglia's writing was useful for clarifying some problems that had arisen in Italian studies on Indian hemp, in particular the set of apparently contradictory data on its physiological effects on humans. Battaglia attributed this variability to the differences in Indian hemp products reaching Europe, which often also contained derivatives of opium, datura and other medicinal plants. In the first part of his article, he described in detail the different products based on Indian hemp, reporting the Arabic commercial names, the

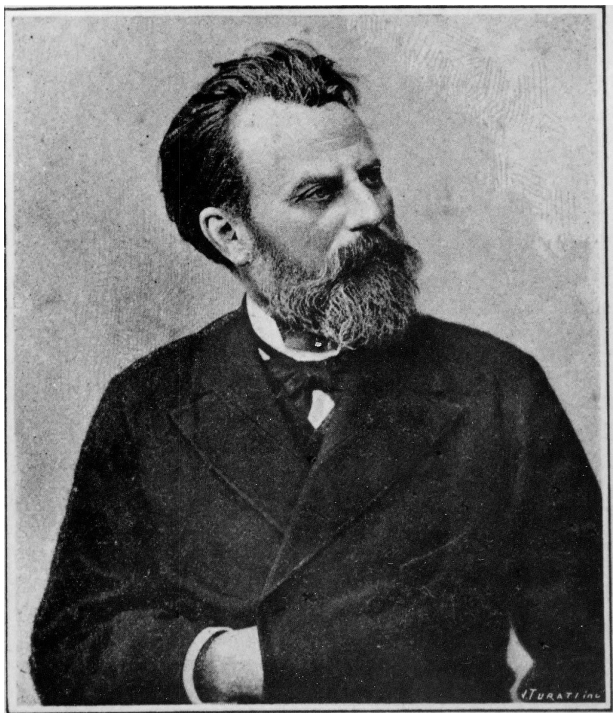

Figure 3: Mariano Semmola (1831-1896) (from Anonymous 1888).

preparation techniques and the methods of intake. Alongside the writing of the French doctor Jean Ernest Godard translated into Italian and published in the Milanese magazine directed by Giovanni Polli (Godard, 1871), the list of Arabic recipes based on Indian hemp exposed by Battaglia is the most extensive in the Italian medical literature of the 19th century, and perhaps even the 20th century. Another cause of contradictions in the medical observations of the effects of Indian hemp was indicated by Battaglia in the failure to take into account the difference in the effects of the drug between individuals who had never taken it –as was often the case in medical observations– and individuals who made continuous use of it. To explain this important difference, the psychiatrist gave the example of alcohol: "*If, to study the consequences of alcohol abuse, it were administered to a teetotaller just once and the symptoms were studied, one would have*

a very insufficient concept of the complex phenomenology of alcoholism" ("*Se per studiare le conseguenze dell'abuso di alcool se ne somministrasse ad un astemio per una volta sola e se ne studiasse la sintomatologia, si farebbe un concetto insufficientissimo della complessa fenomenologia dell'alcoolismo*"; Battaglia, 1887, p. 8). Battaglia continued his dissertation by presenting a learned psychiatric evaluation –despite the limitations of the psychiatric paradigms of those times– of the patients who attended his hospital and who were consumers of Indian hemp. He also performed some experiments on himself, to better understand the phenomenology of the experience with this drug, and to distinguish its "pure" effects from those of preparations that included a combination of hemp with datura or opium; combinations that were frequent in Egypt.

In a writing by Raffaele Valieri –which will be discussed in detail in the next section– this doctor mentioned the fact that his colleague Mariano Semmola, a chief doctor who worked in the Incurabili Hospital, had used Indian hemp shortly before him in some cases of hysteria with mental disorders. Dr. G. Rummo too, director of the *Rivista Clinica e Terapeutica*, had added a note to the Italian edition published in Naples of a treatise on materia medica, in which he reported that "*Semmola assures that he has had good effects of* hachisch *in hysterical young girls, with weak organism, in which disturbances in the psychic sphere predominated*" ("*Semmola assicura di avere avuto buoni effetti dall'*hachisch *in giovanette isteriche, con organismo debole, nelle quali predominavano disturbi nella sfera psichica*"; Nothnagel and Rossbacj, 1882, p. 527). From observation of the extensive medical literature left to us by Semmola, it does not appear that he has published a written report regarding these clinical studies with hemp. Mariano Semmola (1831-1896) (Fig. 3) was an illustrious figure. Of Neapolitan origins, he held various professional positions, including those of Professor of Clinical Therapeutics and Experimental Pharmacology and Dean of the Faculty of Surgical Medicine and Pharmacy of the University of Naples. He was also a politician and held the positions of senator and secretary of the Parliament of the Kingdom of Italy.

Raffaele Valieri's clinical research

One of the most articulate Neapolitan clinical studies on hemp was carried out by Raffaele Valieri. On the frontispiece of his booklets, Valieri reported with a certain pride the long list of titles and awards obtained during his professional activity, including those of Member of the Medical-Surgical Academy of Naples, Commander of the Philanthropic Order of Montréal, Knight of the Crown of Prussia. He also held political offices: he was elected Councillor of the Municipality of Naples four times (in the years 1868-1872) and held the position of Deputy Mayor for a short period. In the years 1865-66 he held the position of President of the Hygiene Commission of the Pendino Section and drafted a Hygiene Report mainly focused on the problem of cholera epidemics, which had some success as it was used as an example in the context of metropolitan hygiene policies of several Italian cities (Valieri, 1867).

Valieri worked as a doctor at the Incurabili Hospital, where, at the time of his clinical research with hemp, he held the position of director of the 3rd women's room. After

much insistence he managed to have an Inhalation Cabinet installed, which he used for the administration of various medicines, including hemp.

Valieri attempted his first therapeutic treatment with Indian hemp in 1874 or 1875, when he treated a case of exophthalmic goitre –also known at the time as "Flajani's disease", nowadays called "Flajani-Basedow's disease"– which resolved in six-month period. In the first phase of the treatment the therapy was based on *cannabene*. This compound was isolated from hemp in France around the mid-19th century (Personne, 1857), but later it was considered a mix of compounds (Vignolo, 1895). Continuing the therapy with nicotine and subsequently with camphor bromide, the patient improved more and more and Valieri, underlining the importance of the therapy with a *Cannabis* preparation, added: "*if another case of exophthalmic goitre with convulsive complications occurs again, I would start always from this precious remedy*" (Valieri, 1875, p. 119).

In the years that followed, Valieri attempted a long series of clinical treatments with Indian hemp and sativa hemp, and in 1887 he set out the results of his research in a booklet entitled *Sulla canapa nostrana e suoi preparati in sostituzione della Cannabis indica* ("On sativa hemp and its preparations in substitution of Indian hemp") (Fig. 4).

He first undertook a series of clinical studies with Indian hemp, which he obtained at a high price on the international market, where it was mostly called *Gaza grass*, but not before having tested its effects on himself. In a couple of places, the doctor made mention of the fact that he suffered from asthma, and that he used both kind of *Cannabis* and *hashish*, smoked, to relieve his ailment.

Valieri administered *hashish* to patients suffering from various conditions, including asthma, pulmonary emphysema, hysteria and "*in other neuroses of central and peripheral origin, in neuralgia of the peripheral nerves, trigeminal, occipital and brachial cervico plexus, lumbar and sacral plexus, in facial and accessory of Willis hyperkinesis*" ("*in altre nevrosi di origine centrale e periferica, nelle nevralgie dei nervi periferici, dei plessi cervico trigemino, occipitale e brachiale, dei plessi lombari e sacrali, nell'ipercinesi facciale e dell'accessorio di Willis*"). He also treated cases of amnesia and "inconsistencies of ideas" positively. His clinical experience made him understand the importance of administering non-intoxicating quantities of this remedy, that is, it was necessary to avoid bringing the patient into a state of *fantasia* (Valieri, 1887, p. 20-30).

Valieri was also interested in the therapeutic properties of sativa hemp, in such an in-depth manner that his clinical studies on this plant can be considered the most extensive not only in Italy but in all of Europe. He started from the observation that the two species of hemp, *indica* and *sativa*, represent the same species, "*and only differ from each other in terms of origin, strength of action, and price*". He complained that the batches of *ascisc* that he was able to obtain at a very high price from abroad differed in purity and therapeutic potential.

Valieri also wanted to personally ascertain the rumours circulating among growers about the alleged intoxicating effects of sativa hemp; rumours that were reported from many places and not just in the Neapolitan area. These effects are not to be confused with other physical intoxications that were attributed to hemp, such as *hemp*

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Prof. V 13

SULLA

CANAPA NOSTRANA E SUOI PREPARATI

IN SOSTITUZIONE DELLA CANNABIS INDICA

PEL

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NAPOLI
STABILIMENTO TIPOGRAFICO DELL' UNIONE
Nell' ex Convento di S. Antonio a Tarsia
1887

Figure 4: Frontispiece of a 1887 booklet by Raffaele Valieri preserved in the Civic Library of Bologna.

fever caused by its pollen, as was believed in the Bolognese area (Mendini, 1907), or nutritional disorders and muscular atrophy, accompanied by feverish events and nervous disorders, observed in France among hemp combers (Salomon, 1893, p. 4). It is interesting to observe how these same French workers experienced these ailments more intensely with hemp of Italian origin, and especially Neapolitan one (*id. p.* 24).

Already at the beginning of the 19th century, the well-known Neapolitan botanist Michele Tenore (1780-1861) believed that hemp sativa gave off an unpleasant, *nidoroso* odour, which had "*the strength to arouse a foggy heaviness in the head*" (Tenore, 1816, p. 230). In 1858, Charles Baudelaire wrote that "*during the harvest of hemp, workers, men and women, suffer similar effects; it seems that a miasma rises from the harvest capable of maliciously disturbing their cerebral faculties. The reaper's head is full of swirls, sometimes full of reveries*" ("*lorsque se fait la moisson du chanvre, le travailleurs mâles et femelles subissent des effets analogues; on dirait que de la moisson s'élève un miasme qui trouble malicieusement leur cerveau. La tête du moissonneur est pleine de tourbillons, quelquefois chargée de rêveries*"; Baudelaire, 1860, p. 15). In the Italian review of O'Shaughnessy's text from 1840, the editor (probably Giovanni Polli), in comparing Indian hemp with sativa hemp, added the consideration that "*even our hemp, when fresh, gives off a virous* odour, *and such that those who allow themselves to sleep in the fields where it grows wake up dizzy, fearful and almost drunk*" ("*anche la nostra, quando è fresca, tramanda un odore viroso, e tale, che coloro che si lascian andar al dormire nei campi ove essa cresce, si destano con vertigini, temulenti, e quasi ubbriachi*"; Redazione, 1840, p. 435). Even among the French growers of sativa hemp, dizziness and a kind of drunkenness had been observed which were believed to be due to the emanations of a volatile principle which the plants emitted even more when the heat was more intense and whose effect was compared to that of chloroform (Salomon, 1893, p.14). The same Valieri learned from a certain Count Spinelli that the farmers at the time of hemp flowering, if they lay down under the shade of the plants, or in the farmhouses located among the crops, or next to the bundles of freshly harvested plants, "*they felt a heaviness in the head, a drowsiness with hallucinations, with strange and fantastic dreams*" (Valieri, 1887, p. 21).

As mentioned, Valieri wanted to personally ascertain these effects, and went to the flowering hemp plantations specifically in the evening, "*when the fragrance of all the herbs becomes more pronounced*". Although he did not experience the fantasy of Indian hemp, he felt a heaviness in the head and an increase in talkativeness which later gave way to a sweet and pleasant drowsiness. During his sleep he had markedly unusual dreams (Valieri, 1887).

These anecdotal data regarding the psychic effects caused by sativa hemp plantations – which I also collected forty years ago from elderly Emilian farmers (Samorini, 1996, p. 18)– do not appear to have ever been scientifically studied.

As regards the therapeutic properties of sativa hemp, starting from the 1850s, i.e., starting from the diffusion of Indian hemp in Italy, alongside the thickest literature concerning the "new" exotic drug, in the medical literature we find reports of pharmacists and doctors who, wondering if

sativa hemp possessed the same therapeutic properties of Indian hemp, had undertaken specific research in this regard.

In a note commenting on a clinical study by the French doctor François Coutenot, Giovanni Polli had underlined the successes obtained with hempseed oil in the treatment of rheumatism and joint pain "*especially in the poor of the mountains, often attacked by these diseases due to the tiring work and the inclement weather to which they are exposed, thus giving them a remedy that is easy and economical to prepare even without the need to resort to pharmacies*" ("*soprattutto nei poveri delle montagne, spesso aggrediti da queste malattie per i faticosi lavori e le inclemenze atmosferiche a cui si espongono, dando così nelle loro mani un rimedio di facile ed economica preparazione anche senza il bisogno di ricorrere alle farmacie*"; Coutenot, 1857, p. 134). In 1864 Pietro Brugo, pharmacist from Romagnano (province of Novara), published a pharmaceutical recipe for the preparation of medicines based on sativa hemp, citing the fact that preparations with this local plant were increasingly requested for the treatment of various ailments. Brugo successfully tested sativa hemp oil as a topical in the treatment of milk engorgement, acute joint pain, gout, and recommended that doctors use this medicine "*to save patients from blisters and other uncomfortable and more expensive therapies*" (Brugo, 1864).

Such was the ethical spirit of these nineteenth-century doctors, doctors who had a limited number of medicines and therapeutic techniques at their disposal, but who were nevertheless moved in the exercise of their profession by humble principles of honesty and humanity. Polli, Brugo, Valieri were concerned about the high price of exotic medicines, in particular Indian hemp, and offered their patients medicines obtained from sativa hemp, available in large quantities and at low cost, as an alternative.

In July 1885, during the hemp flowering period, Valieri went to Casoria to see a certain Don G.P., a rich landowner and at that time a municipal councillor, who acted as a guide to the doctor in his fields cultivated with hemp, for the collection of a certain quantity of selected flowering tops. Valieri first tried the effects of sativa hemp on himself, drinking a decoction of the flowering tops. With a dosage of 4 g dry he felt "*the true phenomena of cannabism* (..) *but very faded and reduced in number and potential*". He experienced similar effects with the resin at dosages of 20 and 40 cg. and came to the general conclusion that in the therapeutic prescription of sativa hemp it was necessary to double the dose compared to the dosage used with Indian hemp (Valieri, 1887, pp. 24-25).

Having identified the therapeutic dosage, Valieri ventured into the clinical applications of sativa hemp. With part of the harvest, he made numerous galenic preparations: distilled water, essential oil, alcoholic and ethereal tinctures, extracts, syrups, tablets, liqueurs, decoctions, infusions, and he also administered the drug to his patients by chewing the herb dried, fumigations, and smoking pipes and cigarettes filled with the vegetable. He found these preparations useful in the treatment of many ailments, from respiratory diseases (asthma, emphysema, chronic catarrhs) to nervous diseases. Hemp cigarettes were useful as a substitute for datura and henbane, Solanaceous plants long used in the

treatment of asthma, but which produce a thick smoke difficult to inhale (Valieri, 1887, p. 14-15).

In another pamphlet by Valieri published the following year (1888), and dedicated to the treatment of exophthalmic goitre with sativa hemp, we learn that Mr. Spinelli was Count Francesco Spinelli of Scalea, at that time Superintendent of the same Incurabili Hospital where our doctor worked. In the preface Valieri mentioned that it was a first booklet of clinical hemp case studies, thus implying that others would follow, which however do not appear to have been published.

In this booklet Valieri reported a long account of the three cases of exophthalmic goitre (all women) that occurred to him in the years 1875, 1884 and 1887 and which, after having in vain tried conventional therapies, he resolved completely with the use of sativa hemp alone. Thus, we see Valieri again in his Inhalation Cabinet intent on administering hemp preparations, also making the patients smoke sativa hemp pipes and cigarettes, and he noted how this method of introducing the medicine was the one preferred by the patients, for whom the smoking desire was so strong that he had to control its therapeutic use to prevent it from turning into "vicious consumption". Within two or three months all three patients recovered completely (Valieri,1888).

The "Calcutta strain" at the Orto Botanico of Naples

The second phase of the Neapolitan history of studies on hemp, dating back to 1931, saw the Orto Botanico of Naples and its Director, Biagio Longo, as protagonist, and concerned the first Italian cultivations of Indian hemp and its diffusion for scientific purposes from Naples to the rest of Italy.

Of Calabrian origins, Biagio Longo (1872-1950) (Fig. 5) initially held the role of assistant at the Botanical Institute of Rome, and then that of professor of botany at the University of Siena and later at the University of Pisa. During the years 1925-1929 he held the position of Director of the Botanical Garden of Pisa, and in 1929 he was called to succeed Fridiano Cavara in the Chair of Botany, and to direct both the Orto Botanico of Naples and the adjoining Stazione Sperimentale per le Piante Officinali (Experimental Station for Officinal Plants), positions he held until 1948. During the Neapolitan phase he had the opportunity to see the happiest and unhappiest moments in the history of the Neapolitan Orto Botanico follow one another, where the unhappiest ones concerned the years of its

Figure 5: Biagio Longo (1872-1950) (from Parisi, 1952). Library of Bologna.

occupation/devastation by of the Anglo-American army (De Luca, 2008-2009).

The creation of the Experimental Station for Officinal Plants in 1928 was part of the directives aimed at the autarchic policies of the fascist regime, and the study of the acclimatization of exotic medicinal plants for their indigenous production had become even more necessary, mindful the consequences of the First World War, which had seen the impossibility of their supply from abroad due to the interruption of relations with the Central Powers, the closure of the two ports of Hamburg and Trieste, and the foreclosure of the Balkan and Russia trade routes (Longo, 1931). During the years 1929-1948, up to 150 different species of medicinal plants were cultivated in the Station, which were studied for the production of strains with a high yield of active ingredients and for the production of seeds which were sent to the botanical and agronomic institutes from all over Italy. Among the most studied species were Indian hemp and the opium poppy.

The problem of the speciation of the *Cannabis* genus was at that time in an effervescent phase of the controversy. A diatribe that was also reflected in Italy, where many scholars –including Antonio Targioni-Tozzetti (1853, p. 92) and the editors of the Official Pharmacopoeia of the Kingdom of Italy– followed the taxonomy decided by Linnaeus, which envisaged the existence of only *C. sativa* species with different varieties (*indica*, *erratica*, *chinensis*). Other authors did not recognize the *indica* as a variety of *sativa* but as its synonym, and among these were Adriano Fiori (1923-1925, I, p. 376) and Filippo Parlatore (1867, IV, p. 308). In Italy there seem to have been few who followed the thesis that the psychoactive variety was a species in itself, *C. indica* Lamarck. Among these there was Biagio Longo. In Pisa he developed a first series of experiments with the aim of studying the differences between sativa and Indian hemp. Many botanists and pharmacologists believed that Indian hemp grown in Europe lost its pharmacological and psychoactive properties and "degenerated" into sativa hemp. Longo wanted to experiment with "the reverse path", that is, he subjected sativa hemp seeds to cultivation with various soil modifications, in particular with the addition of various salts, to see if at least some of the seeds of the plants developed in these conditions could give rise to plants with characteristics similar to those of Indian hemp. The results were negative, and Longo deduced that they were two distinct species. He communicated the results of this research in two conferences held in 1935 in Argentina, in Buenos Aires and in Cordoba (Longo, 1937a).

In 1931, having received *Cannabis indica* seeds directly from Calcutta, Longo began cultivating them at the Experimental Station. To his surprise, all 200 seeds placed in cultivation in March germinated after 17 days. The culture produced 152 dioecious plants (134 females and 17 males) and 60 monoecious plants (Fig. 6). The plants flowered in the second half of September, and initially Longo believed that this had been caused by late sowing, but with the cultivations of the following years he found that September flowering was the norm and was independent of the sowing period (Longo, 1934).

Although lush plants had been obtained in this first cultivation, Longo reported that they were inactive from a pharmacological point of view, while those of the second year (and

all subsequent ones) were powerfully active. This followed *in vivo* experiments developed first, in 1933, by Pio Marfori, who at that time directed the Institute of Pharmacology and Therapy of the University of Naples (Longo, 1934), and a few years later by Vittorio Susanna, of the Institutes of Pharmacology and Pharmaceutical Chemistry of the same University (Susanna, 1936). About ten years later Susanna developed further studies on the Longo hemp strain, confirming that its pharmacological activity was maintained over the generations (Susanna, 1948). Strangely, Susanna never mentioned the first pharmacological works carried out by Marfori, of which he was certainly aware, since in the preambles to the descriptions of his research he always took great care to retrace the history of Longo's Indian hemp strain.

Longo was surprised by the vitality and acclimatisation power of the plants, characterised by notable resistance to low temperatures and which reached a height of 3.5 metres, and even reported the case of a female plant from the 1932 crop that had been abandoned to itself, without care or watering, and which lived until the following year, flowering again. Regarding the problem of speciation of the *Cannabis* genus, with the direct observation of plants of Indian origin Longo became even more convinced that the species he was cultivating was a species distinct from sativa hemp, and that it was the *C. indica* by Lamarck (Longo, 1934).

In the years that followed, Longo continued his cultivation experiences, and sent the seeds of the "Calcutta strain" which reproduced year after year in Naples to various botanical and agricultural institutes throughout Italy. From the detailed reports

Figure 6: Photograph taken in December 1931 of the first Italian cultivation of Indian hemp at the Experimental Station for Officinal Plants of the Botanical Garden of Naples (from Longo 1937a, Fig. 2, p. 349).

that he wrote every year on the activity of the Experimental Station, and which were published in the *Bullettino dell'Orto Botanico* (see for example Longo, 1937b; 1941a), it was possible to follow the Italian diffusion of the Calcutta strain (Fig. 7). In 1939 seeds of this strain were even sent to Addis Ababa, Ethiopia, which was part of Italian East Africa (Longo, 1941b).

Longo's "Calcutta strain" was kept active with annual cultivations for several decades, first at the Experimental Station, and subsequently –following the re-incorporation of the Station in the early 1970s (Zecchino 2005)– at the grounds of the Botanical Garden. Colombo Cavara, who in the 1940s and 1950s was Chief Cultivator

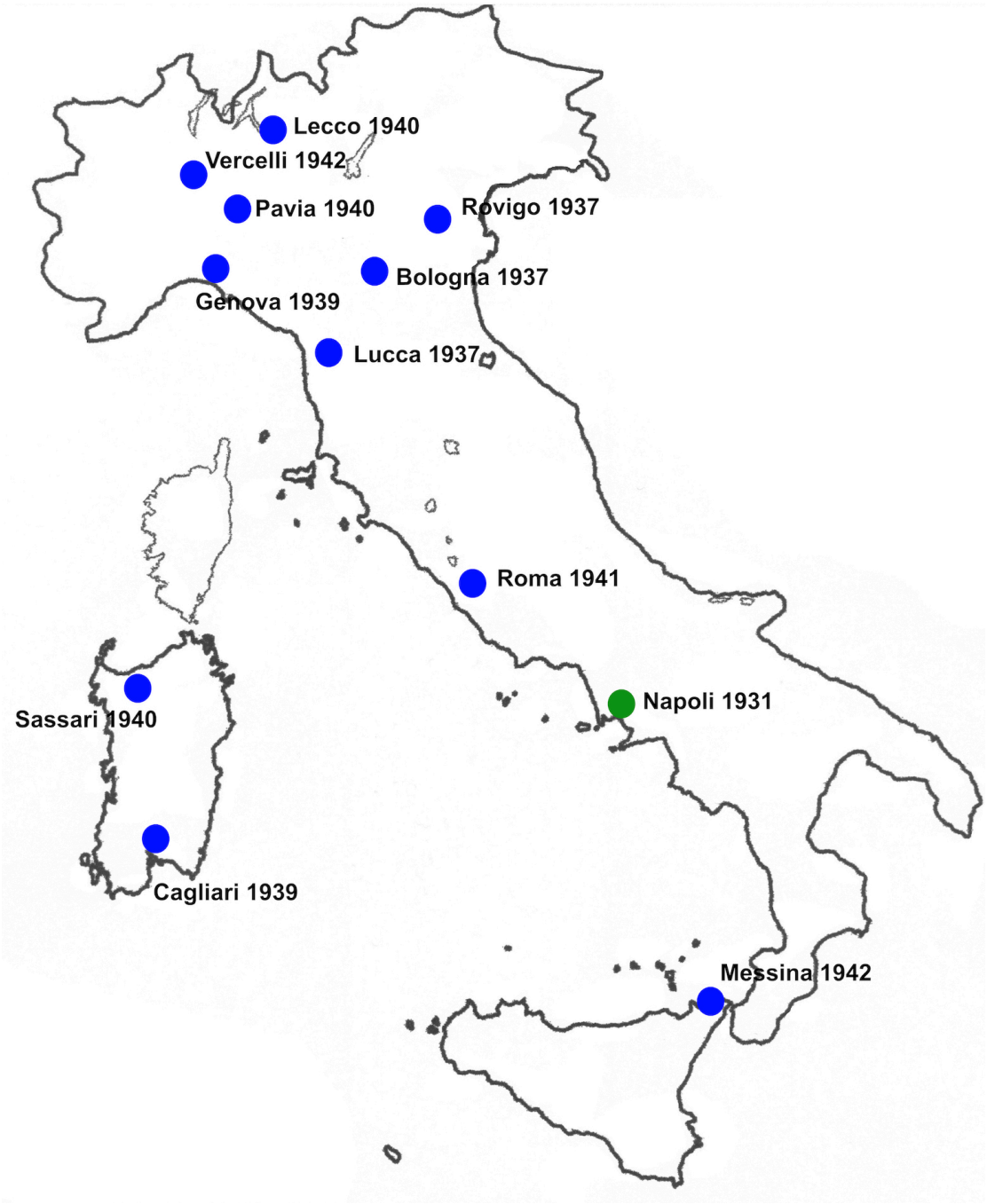

Figure 7: Map of the diffusion in Italy for scientific purposes of the "Calcutta strain" of Indian hemp originated in Naples (author's elaboration).

of the Experimental Station, reported a detailed description of the cultivation technique optimised following decades of agronomic experiences of the Calcutta strain (Cavara, 1955, pp.48-50).

Professor Bruno Menale, a botanist and ethnobotanist who currently works at the Orto Botanico, told me that in the 1990s the Calcutta strain was still cultivated under the guidance of Paolo Casoria, albeit to a lesser

extent than in previous decades. In the 2000s, for a series of reasons (including a decline in interest in phytochemical and pharmacological research on the Calcutta strain, and above all an incessant "predation" by students and visitors), Indian hemp was no longer cultivated. The last cultivated specimen was observed by Menale more than 10 years ago.

For over 50 years the Calcutta strain has been a primary reference sample in phytochemical and pharmacological research carried out in Italy on hemp, both for scientific and forensic purposes.

Among these we must remember the studies conducted by Mario Covello, of the Institute of Pharmaceutical and Toxicological Chemistry of the University of Naples, who based his chemo-pharmacological analyzes on a batch of several kilograms of female inflorescences coming from the 1946 harvest of the Calcutta strain (Covello, 1947; 1948).

Towards the end of the 1930s, Longo sent a quantity of seeds from the Calcutta strain to Professor Puecher of the Agricultural Technical Institute of Sassari. From these seeds Puecher obtained the first Sardinian crops of Indian hemp and delivered the raw product to Giuseppe Carbonaro and Antonio Imbesi of the Institute of Pharmacology of the University of Messina, for pharmacological studies (Carbonaro & Imbesi, 1942). These same authors undertook cultivation of Indian hemp at the Botanical Garden of the University of Messina, with seeds coming from Longo's Calcutta strain. This is the first cultivation of Indian hemp in Sicily (Carbonaro & Imbesi, 1946).

A large set of important and more modern studies on the Calcutta strain was carried out by Gesualdo Siniscalco Gigliano's team of the Department of Biology of the Federico II University of Naples (see for example Siniscalco, 1984; Siniscalco & Di Fizio, 1993-1994) .

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