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Lampione, a paradigmatic case of Mediterranean island biodiversity

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ABSTRACT The papers aims at underlining the “unespected” value of Lampione’s biological heritage, as well as the fragility of its ecosystem. Despite its very little size, this islet harbours a very rich pool of plant and animal species of high biological and/or conservation interest. Special attention is paid to the biogeographic meaning of local endemics, on local extinction and turnover processes, on some ecological or biological patterns which contribute to the distinctiveness of local biota. However, further investigations are needed in order to complete the list of animals and to monitor the demographic trends of all species. In particular, it is necessary to assess if local seagull colony may represent a major threat for local diversity.

KEY WORDS island biogeography; conservation biology; rate of endemism; extinction; micro-insularity.

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INTRODUCTION

In 1960, the German botanist J. Kohlmeyer has entitled a short note “Lampione, an unspoilt island of the Mediterranean” (Kohlmeyer, 1960a). This definition, even if only partially true, is rather representative of the feeling that this islet may transmit to its occasional visitors, especially if they are naturalists.

The extremely isolated geographical position, the low profile that impedes to perceive Lampione (Fig. 1) on the horizon from long distance, the difficulty of landing due to the frequent adverse sea conditions and to old health laws which forbade to visit the islet unless the travelers underwent a long quarantine, and especially the occurrence of just faint traces of an ancient human presence, might do to regard this place as a natural refuge where local biota has not undergone drastic anthropic disturbance that, e.g. in the neighboring island of Lampedusa, has strongly affected the present natural landscape.

Despite this apparent integrity, however, the maintenance of its biodiversity and the risk of a fast environmental degradation seem to be regulated by fragile equilibriums: in fact, a remarkable biological value for Lampione has been highlighted through two centuries of scientific exploration started with G. Gussone, who landed there in August 1828 (Gussone, 1832-1834; 1839), and which has been continued by a number of botanists and zoologists, in particular around the mid-twentieth century, when the Pelagian Islands were studied in the framework of a biogeographical research project coordinated by E. Zavattari (Zavattari et al., 1961).

These investigations provided a rather extensive knowledge on the local floristic and faunal communities (Di Maria di Monterosato, 1892; Giglioli, 1886; 1907; Mertens, 1926; Di Martino, 1958; 1961; Bernard, 1958; Kohlmeyer, 1960a; 1960b; Gridelli, 1961; Lanza & Bruzzone, 1961; Catanzaro, 1968; Moltoni, 1970; Iapichino & Massa, 1989; Beckmann, 1992; Bartolo & Brullo, 1993; Baccetti et al., 1995; Mei, 1995; Cianfanelli, 2002; La Mantia et al., 2002; Pasta, 2002b; 2002c; Sferlazzo, 2003; Goggi, 2004; Lo Cascio, 2004), leading to the description of new endemic taxa (cf. Gussone, 1832-1834; Arcangeli, 1955; Canzoneri, 1972; Di Marco et al., 2002; Brullo et al., 2009; Leo & Lo Cascio, in press); but have also allowed to understand the degree of complexity that, in particular, characterizes the relationships between local plant communities and seagulls, extinction rate, resources sharing, ecological adaptations, etc., under harsh micro-insular constraints (cf. Pasta, 2002b; Carretero et al., 2010; Lo Cascio, 2010; Lo Cascio & Massa, 2010).

In the present paper, an overview of the main biogeographical and ecological traits of that extreme example of Mediterranean insularity represented by the islet is given, based both on the analysis of the available literature and on updated information, obtained during a 10-year field work carried out at Lampione. ABBREVIATIONS. PLC = P. Lo Cascio; SP = S. Pasta.

GEOGRAPHICAL AND HISTORICAL SETTING

Lampione (Fig. 1) (35°33’00” N - 12°19’11” E Greenwich) is the smallest of the Pelagian Islands (Channel of Sicily), with a surface of 0.021 km^2, 750 m of coastal perimeter, and a maximum elevation of 36 m a.s.l. The islet is located 17 km off the W coast of Lampedusa Island, and its morphology is characterized by the occurrence of a flat top which slopes gradually to the East, while the western side is a vertical cliff. Lampione is entirely calcareous, with dolomitized carbonates composed by associated wackestone and packestone referred to the “Halk al-Menzel Formation” (Tunisian offshore, 46-34 Myrs BP: Bonnefous & Bismuth, 1982; Grasso et al., 1985). Thus, it belongs to the African plate and its definitive isolation from North Africa (as well as to Lampedusa) only dates back to the last eustatic sea event (i.e. 18 Kyrs BP).

Except for few meteorological data collected during a physical-astronomical expedition based on the islet in 1971 (Cappatelli & Righini, 1972), no information is available about its climate, although the latter should not differ significantly from that of Lampedusa, with an average annual rainfall and temperature, respectively, of 320 mm and 19 °C (see Pasta, 2002a and references therein). In particular, during the xeric season (from early April to late October), rainfall results generally lesser than 35 mm and average monthly temperature ranges from 18.7 to 26.1 °C (Vittorini, 1973). The islet is now uninhabitated, but an early human presence, probably only seasonal, is evidenced by the ruins of some buildings, which have been referred to the late Roman age (Smyth, 1824; Ashby & Litt, 1912).

Figure 1. The Islet of Lampione, Pelagian Archipelago (Sicilian Channel, Mediterranean Sea).

TAXA	**G**	**DM**	**K**	**SP & PLC**
AIZOACEAE				
Mesembryanthemum nodiflorum L.	x	x	x	x
AMARYLLIDACEAE				
Allium commutatum Guss.		x	x	x
Pancratium sp.		x	x	x
APIACEAE				
Daucus rupestris Guss.	x	x	x	
ASPARAGACEAE				
Asparagus horridus L.		x		x
Bellevalia pelagica C. Brullo, Brullo & Pasta		x	x	x
ASTERACEAE				
Senecio leucanthemifolius Poir. s.l.		x	x	
CAPPARACEAE				
Capparis orientalis Veill.	x	x	x	x
CHENOPODIACEAE				
Atriplex halimus L.	x	x	x	x
Halimione portulacoides (L.) Aellen	x			
Arthrocnemum macrostachyum (Moric.) Moris	x	x	x	x
Sarcocornia fruticosa (L.) A.J. Scott		x		
CONVOLVULACEAE				
Convolvulus lineatus L.		x		
Convolvulus siculus L.		x	x	x
CUSCUTACEAE				
Cuscuta epithymum (L.) L.		x		
EUPHORBIACEAE				
Mercurialis annua L.		x	x	x
FABACEAE				
Melilotus indicus All.		x	x	
Melilotus sulcatus Desf.				x
Medicago truncatula Gaertn.		x		
Lotus edulis L.		x		
FRANKENIACEAE				
Frankenia laevis L.		x		x
MALVACEAE				
Malva veneta (Mill.) Soldano, Banfi & Galasso	x	x	x	x
OROBANCHACEAE				
Orobanche amethystea Thuill.		x		
Orobanche pubescens Dum.-Urv.		x	x	
PAPAVERACEAE				
Fumaria cfr. *bastardii* Boreau				x

PLUMBAGINACEAE				
Limonium albidum Guss.	x	x	x	x
POACEAE				
Catapodium rigidum (L.) C.E. Hubb. subsp. *rigidum*			x	
Dactylis glomerata L. subsp. *hispanica* (Roth) Nyman	x			
Trachynia distachya (L.) Link		x	x	
Hordeum leporinum Link		x		
Parapholis incurva (L.) C.E. Hubb.	x		x	
SOLANACEAE				
Lycium intricatum Boiss.		x	x	x

Table 1. Diachronic list of the vascular flora of Lampione. Families and species are listed in alphabetical order. G: Gussone (1828); DM: Di Martino (from 1955 to 1958); K: Kohlmeyer (1959); SP & PLC (from 2001 to 2010). 1) Before its description, *Bellevalia pelagic*a has been recorded as *Muscari comosum* and *Bellevalia* sp., respectively, by Di Martino (1961) and Kohlmeyer (1960b); 2) according to Domina et al. (2011), locality not confirmed for this species.

Finally, during the 20th century an automatized lighthouse was built by the Italian Navy.

BIOLOGICAL DIVERSITY

Present knowledge on plant and animal diversity and abundance

An up-to-date list of the species of vascular plants recorded for Lampione is given in Table 1. Furthermore, Kohlmeyer (1960b) quoted for the islet two lichens, *Collema* sp. and *Roccella fucoides* (Neck.) Vain., both identified by F. Mattick, while an unidentified mushroom belonging to the genus *Psalliota* has been recently collected by one of us (SP). Reliable data on the population size of plant species are known just for the endemics *Bellevalia pelagica* C. Brullo, Brullo & Pasta (Fig. 11), which occurs with about 60 individuals (Brullo et al., 2009), and *Limonium albidum* Guss., whose consistence may be estimated in 20-30 individuals.

Other species also are represented by few (e.g. *Lycium intricatum* Boiss.) or even by a single individual (e.g. *Asparagus horridus* L.) (Sferlazzo, 2003). Available information on invertebrates (Table 2) is yet partial: in fact, for some faunal groups (Arachnida Acarida, Chilopoda, Insecta Diptera, Insecta Hymenoptera except Formicidae), even if occurring at Lampione, no records are given in literature as well as no specimens were collected or studied during recent samplings; similarly, there are no data on the consistence of local vertebrate populations. For the islet, La Mantia et al. (2002) have listed 39 species of birds, mostly migrants, but also including 4 breeding species: Cory's shearwater, *Calonectris diomedea* (Scopoli, 1769) (Fig. 7), Storm petrel, *Hydrobates pelagicus* (Linnaeus, 1758), Yellow-legged gull, *Larus michahellis* (Naumann, 1840), and Eleonora's falcon, *Falco eleonorae* Gené, 1839 (Fig. 6). Among them, Yellow-legged gull is the largely dominant species in the Lampione ecosystem, with a colony of about 250 nesting pairs; Cory's shearwater and Eleonora's falcon occur respectively with about 50 and 5 pairs, while local consistence of Storm petrel is uncertain, but probably less than 10 pairs (La Mantia et al., 2002; PLC, unpublished data). Apart from an old record of the occurrence of the Monk seal (Smyth, 1824), the only terrestrial vertebrates are the Ocellated skink, *Chalcides ocellatus* (Forsskål, 1775)(Fig. 13), and the Maltese wall lizard, *Podarcis filfolensis* (Bedriaga, 1876) (Mertens, 1926; Lanza & Bruzzone, 1961) (Fig. 5).

Both species are represented on the islet by large populations: using standard methods, Lo Cascio et al. (2006) estimated for Maltese wall lizard a density of 7,500-8,000 individuals/ha (i.e. 15,000-16,800 individuals on the whole islet), while from field observations the ratio of apparent abundance between this species and Ocellated skink was 3:1 approximatively (Carretero et al., 2010), estimating for this latter a probable consistence of about 5,000 individuals.

TAXA		**REMARKS**
GASTROPODA PULMONATA		
Clausiliidae	*Lampedusa lopadusae* subsp. *nodulosa* (Monterosato, 1892)	this taxon has been neglected by authors after its description (see Cianfanelli,2002 and references therein), but should be considered an endemic subspecies (Liberto et al., 2012; Nordsieck, s.d.)
Ellobiidae	*Ovatella myosotis* (Draparnaud, 1801)	
Enidae	*Chondrula pupa* (L., 1758)	
Helicidae	*Cantareus apertus* (Born, 1778)	
	Eobania vermiculata (O.F. Müller, 1774)	
	Theba pisana (O.F. Müller, 1774)	
Hygromiidae	*Caracollina lenticula* (Michaud, 1831)	
	Cernuella virgata (Da Costa, 1778)	
	Trochoidea aff. *cumiae* (Calcara, 1847)	the local population is extremely differentiated from those of Lampedusa and probably belongs to an endemic, undescribed species (Cianfanelli, 2002)
Sphincterochilidae	*Sphincterochila candidissima* (Draparnaud, 1801)	now extinct (Cianfanelli, 2002)
ARACHNIDA PSEUDOSCORPIONES		
Olpiidae	*Calocheiridius olivieri* (Simon, 1879)	**new record**
	Olpium pallipes (Lucas, 1849)	**new record**
ARACHNIDA ARANEAE		
Dysderidae	*Dysdera* sp.	**new record**
Hahniidae	*Hahnia* sp.	**new record**
Gnaphosidae	genus and species unidentified	**new record**
Palpimanidae	*Palpimanus gibbulus* Dufour, 1820	**new record**
Prodidomidae	*Prodidomus amaranthinus* (Lucas, 1846)	**new and first record for Italian fauna**
Salticidae	*Euophrys* sp.	**new record**
MALACOSTRACA ISOPODA		
Armadillidiidae	*Armadillidium hirtum* subsp. *pelagicum* Arcangeli, 1955	uncertain taxonomic status, according to Caruso & Lombardo (1995), who have not seen the type material of this endemic subspecies

TAXA		**REMARKS**
INSECTA ZYGENTOMA		
Lepismatidae	*Ctenolepisma ciliata* (Dufour, 1831)	
INSECTA EMBIOPTERA		
Embiidae	*Embia ramburi* Rimsky-Korsakow, 1905	recorded by Kohlmeyer (1960b) from only one specimen provisionally identified by K. Friederichs; however, other specimens recently collected and now under study show strong morphological differences from *E. ramburi* (PLC, unpubl. data)
INSECTA ORTHOPTERA		
Acrididae	*Calliptamus barbarus* (Costa, 1836)	
INSECTA STERNORRHYNCHA		
Aphididae	*Dysaphis crataegi* (Kaltenbach, 1843)	
INSECTA HETEROPTERA		
Pyrrhocoridae	*Scantius aegyptius* (L., 1758)	
INSECTA COLEOPTERA		
Anobiidae	*Ptinus obesus* Lucas, 1847	**new record**
Apionidae	*Malvapion malvae* (F., 1775)	
Carabidae	*Syntomus fuscomaculatus* (Motschulsky, 1844)	
Cerambycidae	*Parmena algirica* Laporte de Castelnau, 1840	it has been previously referred by Kohlmeyer (1960b) and Sama (1988) to *P. pubescens*; some specimens have been reared from small branches of *Malva veneta*
Coccinellidae	*Tytthaspis* sp.	**new record**
Curculionidae	*Amaurorhinus bewickianus* (Wollaston,1860)	
	Otiorhynchus poggii Di Marco, Osella & Zuppa, 2002	
Dermestidae	*Thorictus* sp.	collected specimens are still under study and probably belong to a N-African species; **new record**
Melyridae	*Aplocnemus pectinatus* (Küster, 1849)	**new record**
Melolonthidae	*Geotrogus vorax* Marseul, 1878	
Mordellidae	*Mordellistena oranensis* Pic, 1900	unique record for Italy (Goggi, 2004)
Tenebrionidae	*Catomus* sp.	collected specimens are still under study and probably belong to a N-African species; **new record**

TAXA		REMARKS
Tenebrionidae	*Eutagenia aegyptiaca tunisea* Normand,1936	**new record**
	Glabrasida puncticollis moltonii (Canzoneri, 1972)	
	Machlopsis doderoi Gridelli, 1930	
	Opatrum validum rottembergi Canzoneri, 1972	
	Tentyria n. sp. Leo & Lo Cascio, in press	the local population belongs to a new species; previously it has been referred to *T. sommieri* (Canzoneri, 1972; Goggi, 2004)
INSECTA LEPIDOPTERA		
Gelechiidae	*Pexicopia malvella* (Hübner, 1805)	
Hesperiidae	*Carcharodus* sp.	
INSECTA HYMENOPTERA		
Formicidae	*Tetramorium* sp.	recorded as *T. punicum* by Bernard (1958) but surely misidentified, according to Mei (1995)

Table 2. List of invertebrates of Lampione. Among orders and suborders, families and species have been listed in alphabetical order. New records (in bold) for Pseudoscorpiones, Araneae and Coleoptera are given on the basis of specimens identified, respectively, by G. Gardini, P. Pantini and PLC; the material is kept in their collections.

PLANT SPECIES	REPRODUCTIVE STRATEGY	DISPERSAL STRATEGY
Allium commutatum	entomogamy	barochory
Arthrocnemum macrostachyum	anemogamy	hydrochory
Asparagus horridus	entomogamy	endozoochory
Atriplex halimus	auto/entomogamy	anemochory
Bellevalia pelagica	entomogamy	barochory
Capparis orientalis	entomogamy	endozoochory
Convolvulus siculus	entomogamy	barochory
Frankenia laevis	entomogamy	barochory
Fumaria cf. *bastardii*	autogamy	barochory
Limonium albidum	entomogamy	epizoo/barochory
Lycium intricatum	entomogamy	endozoochory
Malva veneta	entomogamy	barochory
Melilotus sulcatus	entomogamy	epizoochory
Mercurialis annua	entomo/anemogamy	myrmecochory
Mesembryanthemum nodiflorum	entomogamy	barochory
Pancratium sp.	entomogamy	barochory/hydrochory

Table 3. Reproductive and dispersal strategies of the vascular plants occurring at Lampione.

Conservation status

Despite the very small geographical range and size of their populations, neither of the two endemic plant species of Lampione is protected by national and regional legislation. More in detail, three species figured within the regional red lists concerning Italian vascular plants compiled by Conti et al. (1997). Following IUCN risk assessment, *Daucus rupestris* (apparently extinct on the islet) is considered "EN" (= endangered), while to *Limonium albidum* and *Lycium intricatum* the risk category "LR" (= Low risk) was assigned.

Among them, only *Daucus rupestris* still figures within the updated red list of Raimondo et al. (2011). For the recently described *Bellevalia pelagica*, Brullo et al. (2009) have proposed the IUCN risk category CR (= "Critically endangered") B2ab (ii,v); C2a (ii). Also the occurring endemic invertebrates (see below) are not protected by the existing legislation. In contrast, Maltese wall lizard and Ocellated skink are included in the Annex 4 of the EU Directive 92/43 "Habitat" and in the Annex 2 of the Bern Convention.

The local avifauna also has great importance in conservation terms: Storm petrel, Cory's shearwater and Eleonora's falcon are listed in the Annex 1 of the EU Directive 09/147 and in the Annex 2 of Bern Convention; the latter two are also classified as SPEC2 (species whose breeding population is mainly concentrated in Europe, with unfavourable conservation status) according to BirdLife International (2004).

BIOGEOGRAPHICAL AND ECOLOGICAL TRAITS

Endemism and high biological value

The recently censused flora (Table 1) comprises 16 species, which include *Limonium albidum* and *Bellevalia pelagica*, both exclusive endemics of the islet; therefore, the rate of endemism is equal to 12.5%, which results relatively high in comparison to that known for the circum-Sicilian islands (cf. Pasta, 1997; Mazzola et al., 2002; Bocchieri & Iiriti, 2011).

However, remain still unclear both the identity and the taxonomic status of the local population of *Pancratium*, previously recorded by Kohlmeyer (1960b) and Di Martino (1961) as *P. maritimum* L. In fact, although De Castro et al. (2012) did not find any genetic differences from the "typical" sea daffodil, according to numerous ecological, morphological and biological evidences (SP, unpublished data), it could belong to a different species, not ruling out a priori that it may be another endemic element of the islet flora.

In this case, the rate of endemism should increase to 18.7%, reaching an outstanding level for such a tiny Mediterranean islet. Morphological (Colombo & Trapani, 1992) and caryological (Brullo et al., 1995) data suggest that *L. albidum* is closely related to *L. lopadusanum*, which occurs on the other Pelagie islands (Brullo, 1980). They both belong to a quite isolated group of diploid *Limonium* species, such as *L. panormitanum* (Tod.) Pignatti (NW Sicily), *L. hyblaeum* Brullo (Egadi Archipelago and SE Sicily) and *L. mazarae* Pignatti (SW Sicily) (Brullo & Pavone, 1981; Trapani et al., 1997). Interestingly, a closely related species, *Limonium cyprium* (Meikle) Hand & Buttler, is endemic of the northern coasts of Cyprus (Hand, 2003). Due to its striking resemblance, it was first described as a subspecies of *Limonium albidum* (Meikle, 1983), then considered to fall within its variability (Greuter et al., 1989). The recently described *B. pelagica*, instead, seems to be closely related to other narrow endemics of the *Bellevalia romana* subsection, like the N African *B. dolichophylla* Brullo & Minissale, from Cap Bon (NE Tunisia), and *B. galitensis* Bocchieri & Mossa, from La Galite Island (off the N coast of Tunisia) (Brullo et al., 2009).

Also the group of exclusive endemic invertebrate taxa is rather rich: it surely includes the snail *Lampedusa lopadusae* subsp. *nodulosa* (Monterosato, 1892), and the beetles *Otiorhynchus poggii* Di Marco, Osella & Zuppa, 2002, *Glabrasida puncticollis* subsp. *moltonii* (Canzoneri, 1972) (Fig. 12), *Opatrum validum* subsp. *rottembergi* Canzoneri, 1972, and *Tentyria* n. sp. (Leo & Lo Cascio, in press). *L. nodulosa* is closely related to another Pelagian endemic, the nominal subspecies *L. lopadusae* (Calcara, 1846), which inhabits Lampedusa, and belongs to a group of species with mostly E Mediterranean distribution which includes other insular endemics in the Maltese Archipelago (Giusti et al., 1995; Liberto et al., 2012; Nordsieck, s.d.). The weevil *O. poggi* is morphologically comparable with the Sicilian species belonging to the group of *O. cribricollis* Gyllenhal, 1834 (Di Marco et al., 2002). The new *Tentyria* Latreille, 1802 shows a remarkable affinity with some N African congenerics (Leo & Lo Cascio, in press), while the two endemic subspecies of *O. validum* and *G. puncticollis* belong to a W Mediterranean and a N African complex of geographical taxa, respectively (Aliquò & Soldati, 2010). According to Caruso & Lombardo (1995), further investigations are needed to clarify the taxonomic status of the Isopod *Armadillidium hirtum* subsp. *pelagicum* Arcangeli, 1955, while the endemic fauna could include also an undescribed snail of the genus *Trochoidea* Brown, 1827 which so far has been referred to *T. cumiae* (Calcara, 1847), occurring in the nearby Lampedusa Island (cf. Cianfanelli, 2002).

Among the different faunal groups, Coleoptera Tenebrionidae are characterized by the highest level of endemism, equal to 50% of the specific and infraspecific taxa; besides, they include *Machlopsis doderoi* Gridelli, 1930, an endemic species with N African affinity which inhabits also Lampedusa and the nearby Conigli Islet. Furthermore, present data show as Lampione represents the only Italian locality known for *Prodidomus amaranthinus* (Lucas, 1846), a spider distributed in the Mediterranean area (cf. Platnick, 2009), and for *Mordellistena oranensis* Pic, 1900, a N African Mordellidae (Goggi, 2004). The same is highly probable for the beetles belonging to genera *Thorictus* Germar, 1834 and *Catomus* Allard, 1876, recently collected on the islet and whose identification is still in progress, as well as for the webspinner recorded as *Embia ramburi* Rimsky-Korsakow, 1905 by Kohlmeyer (1960b), which surely belongs to an unidentified (probably N African) species (PLC, unpublished data). Further investigations will allow to assess the identity of an ant erroneously referred to *Tetramorium punicum* (Smith, 1861) by Bernard (1958; cf. Mei, 1995) and still unidentified; like other Pelagian populations, it must be closely related to N African ones (Sanetra et al., 1999).

If the close faunal relationship between Lampione and North Africa, as well as in the case of Lampedusa, is easily explained in light of paleogeographic data, the overall biological value of the islet is further enhanced by the occurrence of two N African beetles, the melolonthid *Geotrogus vorax* Marseul, 1878 and the tenebrionid *Eutagenia aegyptiaca* subsp. *tunisea* Normand, 1936, for which the Pelagian Archipelago is the unique Italian area where they have been recorded (cf. Baraud, 1985; Aliquò & Soldati, 2010). The only endemic vertebrate is the Maltese wall lizard, here represented by the subspecies *laurentiimuelleri* (Fejérváry, 1924) which exclusively inhabits this islet, Linosa Island, and was recently introduced at Lampedusa (Lo Cascio & Corti, 2008). Despite the remarkable geographical distance between the Pelagian and the Maltese Archipelago from these island, the populations are genetically very little differentiated from each other, and this suggests a relatively recent colonization of Linosa and Lampione by this species (Scalera et al., 2004).

Dispersability

The analysis of the dispersal modes of plants provides an unexpected result for an islet where seabirds seem to represent the main ecological constraint for vegetation composition, structure and dynamics (Table 3).

In fact, endozoochory and epizoochory are equal, respectively, to 18.7% and 12.5%, while the prevailing dispersal is barochory (56.2%), not including in this category a species characterized by mixed strategies (*Limonium albidum*). In the same way, other long- (hydrochory and anemochory) and short-distance dispersal modes (myrmecochory) are less represented in the islet's flora, all equal to 6.2%.

Finally, it is noteworthy that within Coleoptera are largely prevailing wingless or brachypterous species, for an amount of about 60% of the whole fauna. This order includes all the four endemic insects exclusively known for the islet, and all them are also unable to fly.

Extinctions and turn-over

In Table 1 are summarized the results of the floristic surveys carried out at Lampione during the early 19th century (by G. Gussone), half of the 20th century (by A. Di Martino and J. Kohlmeyer) and by us during the last decade.

Whereas Gussone's visit took place in full summer (August), so that some dormant species might therefore have escaped to his observations, the number of taxa (10) he found sounds reliable. Moreover, the same Gussone (1839) writes: “le piante fanerogame di Lampione non oltrepassano le 20 specie” [the flowering plants of Lampione did not surpass 20 species]. The comparison between the data provided by Di Martino (1961) and Kohlmeyer (1960b), who have recorded 26 and 19 taxa respectively, and those collected during the most recent samplings, carried about half century later, shows that during this period several extinctions have occurred: in addition to one species (*Fumaria* cf. *bastardii* Boreau) that could have colonized the islet just recently, only 15 out of the 32 previously recorded taxa still form part of the present floristic assemblage; noteworthy, none of the 5 species belonging to family Poaceae results confirmed, as well as Apiaceae, Asteraceae, Cuscutaceae and Orobanchaceae are no longer represented in the islet flora. This loss of biodiversity may be the result of the increasing disturbance due to local seagull colony (Pasta, 2002b).

The massive presence of gulls, in fact, produces strong changes in habitat structure, particularly in small islands where ecosystems are extremely vulnerable (cf. Vidal et al., 1998). Seagull activity determines direct and indirect effects mainly on plant communities (Figs. 8, 9), both for i) physical disturbance and damages due to nesting, trampling, etc.; ii) chemical and physical alterations of the soil, due to the sensitive input of nutrients and organic matter which in turn triggers nitrification and eutrophication processes (Anderson & Polis, 1999; García et al., 2002). Unfortunately, the trend of the local seagull population during the last half century is unknown, and few indirect information are given by Moltoni (1970), which in April 1967 has seen “diverse coppie nidificanti” [several breeding pairs]: this observation seems rather simplistic compared to the current noteworthy size of the colony, which includes about 250 pairs (PLC & SP, unpublished data), thus it can be assumed that over the last few decades there has been a significant increase.

Also the apparent population decline and spatial segregation of the colony of Eleonora’s falcon, more than the area occupied by gulls, could be other indirect evidence of this trend: in August 1882, Giglioli (1907) had found 12 pairs of this species nesting on the open spaces of the top plateau of the islet, now massively occupied by the seagull colony, while the recently censused 5 pairs are occur-

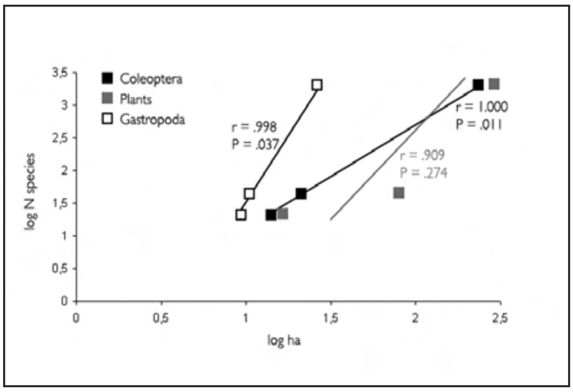

Figure 2. Log species-log area curves for Coleoptera, Gastropoda and vascular plants of Lampione, Conigli and Lampedusa. Data sources: Goggi (2004) and present paper, for Coleoptera; Cianfanelli (2002), for Gastropoda; Pasta (2001; 2002b), for vascular plants.

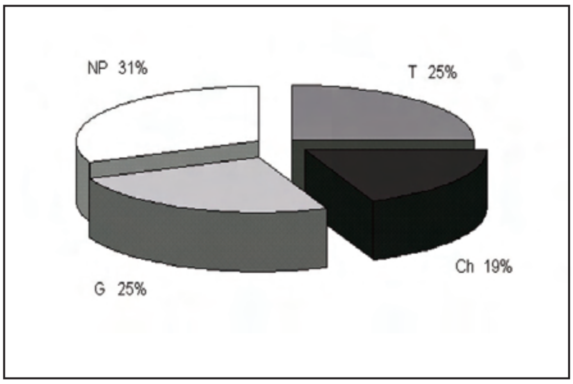

Figure 3. Life-form spectrum of the Lampione flora. Ch: chamaephytes; G: geophytes; NP: nano-phanerophytes; T: therophytes.

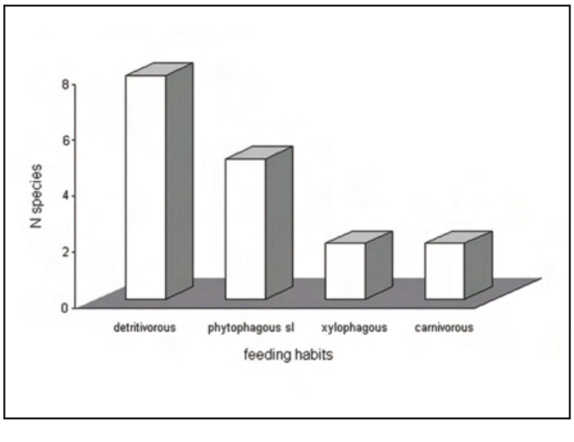

Figure 4. Frequency of trophic categories among the Coleoptera of Lampione.

ring exclusively in the western cliff, less frequented by other birds (PLC & SP, pers. observ.). Anyway, contrary to what occurs in other micro-insular environments, where seagull disturbance has determined the entry of ruderal and/or nitrophilous plant species (cf. Bocchieri, 1990; Vidal et al., 2000; Caldarella et al., 2010; Lo Cascio & Pasta, 2011), at Lampione it has caused local extinctions but not a true turnover process.

Although seagulls might have favoured the expansion of some ornithocoprophilous species already occurring in the islet, such as *Malva veneta* (Mill.) Soldano, Banfi & Galasso, no data are available to assess the possible changements affecting the spatial distribution and the floristic composition of local vegetation. Considering the extinction rate within life-form groups (sensu Raunkiær, 1934), Pasta (2002b) highlighted that Lampione is characterized by a higher mean value (50.0) compared to Lampedusa (25.3) and Conigli Islet (31.0).

It has involved especially hemicryptophytes (100.0) and therophytes (76.5), while other groups result less (nano-phanerophytes: 16.7) or not affected (0 value for both geophytes and chamaephytes) by extinctions. Finally, there are no comparable data for faunal inventories, and in all likelihood some invertebrates might have been neglected or not seen during previous samplings. The only documented extinction concerns the snail *Sphincterochila candidissima* (Draparnaud, 1801), for which just shells without living animals were found on the islet (Cianfanelli, 2002).

Species poverty

Islands typically have fewer species per unit area than mainland, and intra-archipelago species-area curves are steeper the smaller is the surface of each island (Rosenzweig, 1995; Whittaker, 1998). Three groups (Coleoptera, Gastropoda and vascular plants) offer a good example of this insular trait. In fact, comparing Lampione with Lampedusa and Conigli Islet, whose surface is respectively 20.20 and 0.044 km^2, species$_{\log}$-area$_{\log}$ correlation resulted highly significant for beetles ($P = 0.011$) and snails ($P = 0.037$), while for plants no significant correlation occurs ($P = 0.274$) (Fig. 2). This result suggests that plant richness may be influenced by other geographical features, and primarily by the distance from the main pool source: in fact, Conigli Islet, located few meters off the S coast of Lampedusa, harbours 78 species vs. 16 censused on the farthest Lampione.

Micro-insular and local disharmony

Using the term “disharmony”, island biogeographers indicated the different balance of species compared to equivalent patches of mainland. In fact, islands are disharmonic as their biotas depend only from the dispersive portion of the mainland pool, but this fact must be distinguished from simple impoverishment, as it should not be merely a random subset of a potential mainland pool that is missing (Whittaker, 1998).

Concerning Lampione, which has a continental origin and whose definitive isolation occurred rather recently, disharmony should not be related to dispersal ability of propagules, while it could reflect other constraints (e.g. climatic features, soil composition and structure, etc.), mostly still unclear, which seem to have acted as selective forces in the assemblage of its unbalanced ecosystem. Life-form spectrum of plant community results disharmonic, due to the exceptionally low number of therophytes (representing 60% of the whole Pelagian vascular flora, see Mazzola et al., 2002) and, contrariwise, to the abundance of nano-phanerophytes (Fig. 3). Anyway, the latter is a rather common pattern in other circum-Sicilian islets (Pasta, 1997), while the unusually low representation of the annual species depends from the above-mentioned loss of plant diversity which occurred during the last 50 years.

Furthermore, it should be noted the absence of some life-form groups (hemicryptophytes, phanerophytes) which instead are found in the plant communities of other tiny islets, such as Conigli (Pasta, 2002b). A certain degree of disharmony characterizes also the invertebrate fauna. For instance, Tenebrionidae are equal to 35% of the whole coleopteran species, and to 14% of the invertebrates occurring at Lampione. To better understand this fact, it should be considered that this family represents only 11% of the coleopteran fauna in the near Lampedusa Island.

The over-representation of darkling beetles is assumed to be a typical trait of micro-insular environments indeed: at Alborán, an islet of 0.071 km^2

of surface that lies in the middle of the homonymous sea channel between S Spain and N Morocco, this group is equal to 60% of the local coleopteran assemblage, which includes 10 species, and about 16% of the whole terrestrial invertebrates (Aguirre, 2006).

On the contrary, the low number of Gastropoda recorded on this islet (1 vs. 9 occurring at Lampione: cf. Aguirre, 2006; Cianfanelli, 2002) depends from the geological origin of the islets, because snails are generally less abundant on volcanic base-poor outcrops such as those of Alborán.

Also, an over-representation concerns the trophic groups of Coleoptera, where detritivores (which include *Ptinus obesus* Lucas, 1847, *Thorictus* sp. and all the Tenebrionidae) are extremely abundant if compared to other groups which usually are dominant in Mediterranean environments (such as phytophagous, including anthophagous and rhyzophagous species) (Fig. 4). However, the latter could be explained by the abundance of debris that, in addition to the litter produced by the biological cycle of plants, at Lampione is due to the presence of a large gull colony.

Another disharmonic trait of the islet biota is represented by the composition of local herpetofauna, which includes two Saurians belonging to Lacertidae and Scincidae but no Gekkonidae. This fact strikes attention, because Gekkonidae i) are extremely common in the xeric environments of other Pelagian Islands, and ii) are generally more able than other Reptiles to survive in very small insular areas (Corti et al., 2006; Lo Cascio & Corti, 2008).

Considering that Lampione harbours the likely autochthonous *Chalcides ocellatus*, it is difficult to explain the absence of *Tarentola mauritanica* (L., 1758), a species widely distributed on the nearby areas (Lampedusa, Conigli and North Africa) which were repeatedly connected to this islet during the last marine regressions, unless we suppose that the present herpetofaunal disharmony hides supervening events that may have caused a local extinction.

Ecological or evolutionary responses?

Islands are commonly indicated as both evolutionary and ecological laboratories. Short- and long-term changes occurring in life history of island species may be combined under the term of "island


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Figure 5. A male of *Podarcis filfolensis* climbing on *Malva veneta* in search of food. Figures 6, 7. An overview on the biodiversity of Lampione: a young *Falco eleonorae*, October 2005 (Fig. 6.) *Calonectris diomedea* in the nest, June 2005 (Fig. 7).

phenomenons", or "island rule" in its wider significance (Fernández-Palacios, 2010). However, it is not always clear whether processes and mechanisms of insular adaptation reflect ecological or evolutionary time-scales. For instance, if further research will confirm the identity of the *Pancratium* sp. found at Lampione as *P. maritimum*, as previously reported by Di Martino (1961) and Kohlmeyer (1960b), its ecology would represent an uniqueness in the context of the Mediterranean populations of the species.

In fact, Sea daffodil is a stress-tolerant and psammophilous pioneer typical of the embryonic sand dunes, but in this islet it occupies a sharply different niche, adopting a new primary strategy (sensu Grime, 2001) and acting as ruderal-nitrophilous and lithophilous species. An unusual pupation strategy is acted by the endemic *Glabrasida puncticollis moltonii*, whose nymphs develop inside cocoons. This is very likely an exceptional behaviour among the species belonging to this genus, but remains under debate if it represents a distinctive trait of the Lampione population life-history in evolutionary terms or, as more reliable, a peculiar (or seasonal) adaptation to special environmental conditions (e.g. prolonged and strong drought period, soil scarcity, etc.) (Lo Cascio & Massa, 2010).

Finally, lizard populations at Lampione show ecological traits typically related to micro-insularity, such as i) high population density, and ii) elevated levels of intra- and interspecific competition, measured as tail autotomy, cannibalism and predation rates (Lo Cascio et al., 2006; Carretero et al., 2010). In other tiny Mediterranean islets has been observed that the occurrence of large colonies of seabirds is often closely related to that of high lizards' densities (Pafilis et al., 2009).

Gulls do not prey generally on lizards, while the latters appear to profit from gull presence in different ways: Moltoni (1970) recorded as occasionally kestrels, *Falco tinnunculus* Linnaeus, 1758, preyed on lizards, but most of the year gull aggression discourages lizard predators near the islet; and, more importantly, it is well known as gulls subsidize islet ecosystems by importing nutrients in form of guano, carcasses, fish scraps, etc. (cf. Anderson & Polis, 1998), thus supporting dense lizard populations (Markwell & Daugherty, 2002; Barrett et al., 2005; Pafilis et al., 2009). In this regard, a very significant episode was reported by Moltoni (1970) as follows: "vidi una lucertola, la quale per la sete che aveva, leccava i liquidi che uscivano da un uovo nel quale il piccolo aveva già rotto il guscio" [I saw a lizard, which for the thirst that had, was licking the fluid coming out from an egg already broken by a hatchling (of gull)]. Both Maltese wall lizard and Ocellated skink at Lampione also show high rates of tail autotomy or injuried tails (Lo Cascio et al., 2006; PLC & SP, unpublished data), which seem to be related likely to high intra- and interspecific aggression than the occurrence of predation pressure.

This behaviour is confirmed by the cases of cannibalism reported for the Maltese wall lizard and predation on the latter by Ocellated skink, reflecting the moderate diet overlap due to the convergence in trophic strategies between the two species (Carretero et al., 2010). In fact, *Chalcides ocellatus* preys upon medium- or large-sized beetles and insect larvae, while the diet of *P. filfolensis* is mainly based on ants and smaller preys not consumed by the skink, but both species share a remarkable consumption of vegetal matter. While partial herbivorism is relatively common among insular lacertid lizards (cf. Pérez-Mellado & Corti, 1993), it is absolutely unknown for continental populations of Ocellated skink whereas it has been found just within insular ones (Lo Cascio et al., 2008); for this species, there is also a trend for increasing the degree of herbivory with isolation and island surface decrease, as confirmed by the very high proportion (about 50%) of vegetal matter recorded in the Lampione diet (Carretero et al., 2010).

Therefore, in this case evolutionary history, rather than resource partitioning, seems responsible for the moderate trophic overlaps found and even may explain why both species coexist under the severe conditions of Lampione.

Is there an adequate pollination network?

Although a specific study on local pollinators was never carried out, during ten years of field work on the islet a number of empirical observations on plant-animal relationships have been gathered by the authors, especially as regards pollination mechanisms. The main bulk of local flora consists of entomogamous plants, equal to 75% of the occurring species, while self- and wind-pollinated plants are both equal to 12.5% (Table 3).


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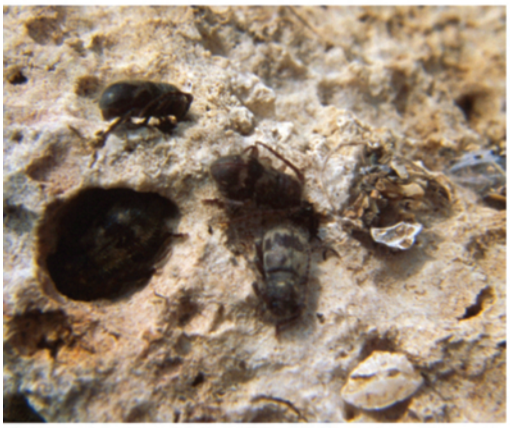
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Figures 8-13. An overview on the biodiversity of Lampione. Fig. 8. The flat top as it appears in July. Fig. 9. The same in May, during the breeding season of *Larus michahellis*. Fig. 10. *Parmena algirica* under stones. Fig. 11. A blooming *Bellevalia pelagica*. Fig. 12. *Glabrasida puncticollis moltonii* inside its pupal coocon (photo by B. Massa). Fig. 13. *Chalcides ocellatus*.

Efficient pollinators, such as Diptera Syrphidae or Hymenoptera Apoidea, have been rarely seen as flower visitors, perhaps because permanent populations are lacking on the islet, that they can reach occasionally thank to their high dispersal ability: for instance, just one unidentified Hymenoptera (probably an Halictidae bee) has been found on flowers of *Bellevalia pelagica* (SP, unpublished data).

Conversely, Diptera Calliphoridae and Muscidae were found with remarkable frequency on flowers and are very abundant at Lampione, as these flies depend from avian wastes for their larval growth, but are generally considered less efficient pollinators (Kwak & Bekker, 2006; Pérez-Bañon et al., 2008). Therefore, it is rather intuitive that, similarly to other insular ecosystems (cf. Olesen et al., 2010), the pollination network of this islet results extremely simplified, and further investigations may clarify to what extent lack of adequate pollinators or small pollinating fauna could affect the reproductive biology of the local plant community.

Anyway, it can be preliminarily assumed that small population sizes, together with the shortness of blooming period, might expose to a greater risk some species (e.g. *B. pelagica*) under these severe constraints. If pollination plays a significant role in the maintenance of genetic variability and fitness of plants, and pollinator scarcity may lead in some cases to local extinctions (Barrett, 1996), it cannot be excluded that this factor could have contributed to some extent to the loss of plant diversity occurred during the last fifty years. Finally, it remains unclear the role of Maltese wall lizard as potential pollen vector, especially on large-sized individuals of plants such as those of the biennal *Malva veneta*, where the lizards were frequently observed climbing, apparently in search of flies and other insects (PLC & SP, unpublished data).

Lizards could play an important role also as "vicariant" pollinators of *Allium commutatum* and *Pancratium* sp., as already observed in some islets of Balearic Archipelago for the relatives *Allium ampeloprasum* L. and *Pancratium maritimum* L. by Pérez-Mellado et al. (2000). In particular, *Pancratium* sp. has morphological traits that favour pollination by hawkmoths ("sphingophyly" sensu Manning & Snijman, 2002), but its local population blooms just 1-2 weeks around mid-September, when the weather is often characterized by rather unsteady and windy conditions.

These conditions can result less favourable for "optimal" pollinators like *Macroglossum stellatarum* L., 1758 (Eisikowitch & Galil, 1971) than for lizards, which show a strong propensity for the consumption of vegetal matter.

CONCLUDING REMARKS: HOW FRAGILE AND KNOWN IS LAMPIONE ECOSYSTEM?

With its unsteady plants species' assemblage and its extraordinary concentration of "classical" examples of micro-insularity, apparently far from human disturbance but actually suffering some undecifered form of degradation, Lampione represents a paradigmatic example of Mediterranean islets realm, which an increasing attention has been paid to in the recent past (Delanoë et al., 1996).

Some twenty years ago Greuter (1991) argued that extinction occurred very rarely within Mediterranean basin. On the other hand, the available data on the evolution of the plant assemblages of the circum-Sicilian islands (Pasta, 1997) suggest that this statement is not totally correct. In fact, many species, also endemic ones, have disappeared in last decades. Also some of the most noteworthy plants of Lampione underwent strong rarefaction (*Limonium albidum*) or even local extinction (*Daucus rupestris*) within last 50 years. As a matter of fact, our fragmentary knowledge on the history of local plant and animal populations does not enable to disentangle biological crisis from normal turn-over processes (Diamond, 1976), so that it is hard to forecast the future of the biological heritage of Lampione.

Nevertheless, the sharp changes which recently affected both plant species number and the distribution and cover rate of local vegetation, suggest the importance of regular monitoring activities, as recommended by the Management Plan concerning the SCI ITA040002 "Isole di Lampedusa e Lampione" (La Mantia et al., 2009).

As recently pointed out by Domínguez Lozano et al. (2003), in order to develop a coherent and effective plant conservation strategy at least three factors should be taken into account: the environmental range of each species, its level of geographic rarity (both on the local and the whole distribution range level) and its rate of threat (resulting from two opposite patterns: anthropogenic interaction and level of protection).

Although it is often difficult and dangerous to make generalisations about the influence of biological variables on rarity and threat, in our opinion future field investigations should be concern the biology (life-cycle, reproduction and dispersal vectors, etc.) of Lampione's "botanical highlights" and to better evaluate the environmental effect of local seagull colony.

Further studies are also needed in order to improve the faunal knowledge and to monitor the demographic trends of some species of conservation interest, such as the marine birds and the Eleonora's falcon. Finally, the identity of some invertebrates that are currently identified only at generic rank, as well as the taxonomic status of other faunal elements previously attributed or probably belonging to endemic forms, need to be investigated in order to understand properly the biogeographical importance and meaning of local biological heritage.

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