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BREEDING SHEARWATERS ON ITALIAN ISLANDS: POPULATION SIZE, ISLAND SELECTION AND CO-EXISTENCE WITH THEIR MAIN ALIEN PREDATOR, THE BLACK RAT

Abstract – We review and update available information on the population size and distribution of Cory's Shearwater, *Calonectris diomedea,* and Yelkouan Shearwater, *Puffinus yelkouan,* in Italy. More than 90% of the population of these species rely on 64 islands, but the former breeds on twice as many islands as the latter. Some cases of local extinction were recorded. The analysis of distributions, along with that of island features and presence of rats, showed inter-specific differences. The Yelkouan Shearwater tends to occupy larger and more offshore islands than the other species does. It's the only one that shows a clear positive correlation between abundance and island size. Finally, it is not present in rat-free islands, with a single exception of no quantitative relevance. Available data on the breeding success of both species are presented; complete failures where rats occur were recorded. Operations of rat control or eradication are presented and their consequences on seabirds' breeding success commented.

Key words – Calonectris diomedea, Puffinus yelkouan, Rattus rattus, breeding success, rat eradication, Italian islands.

Riassunto – *Le berte nidificanti sulle isole italiane: popolazione, selezione delle isole e convivenza con il principale predatore alloctono, il Ratto nero.*

Viene presentata una revisione e un aggiornamento dei dati di popolazione e distribuzione delle due specie di berte nidificanti in Italia. Più del 90% delle coppie di entrambe risultano insediate su un totale di 64 isole, con la Berta maggiore presente nel doppio di isole rispetto alla minore. Vengono documentati alcuni casi di estinzione locale. L'analisi delle distribuzioni, a fronte delle caratteristiche dei siti e di dati sulla presenza dei ratti, evidenzia differenze fra le due specie. La Berta minore tende ad occupare isole mediamente più grandi e distanti da terra, è l'unica a mostrare una chiara correlazione positiva tra abbondanza e ampiezza dell'isola, ed infine è in prati-

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ca assente su tutte le isole prive di ratti. Vengono riuniti e commentati i dati disponibili sul successo riproduttivo di entrambe le specie, comprensivi di casi di fallimento totale su isole con presenza di ratti, nonché sulle conseguenze degli interventi finora svolti di eradicazione e contenimento locale del predatore.

Parole chiave – Calonectris diomedea, Puffinus yelkouan, Rattus rattus, successo riproduttivo, eradicazione dei ratti, isole italiane.

Introduction

Monitoring distribution and abundance of species is necessary for determining conservation priorities, sound management strategies and consequent actions (SUTHERLAND *et alii*, 2004; NICHOLS & WILLIAMS, 2006). The marine bird community of the Mediterranean, not particularly rich in species but featured by a high level of endemism, has been shaped by millennia of co-existence with man, which caused the lost of many taxa since the very start of human history (ZOTIER *et alii*, 1999). Not surprisingly, also in the present time, man-related threats to seabird populations of this heavily developed sea basin represent a critical conservation issue, as shown by the contents of several single-species action plans produced at a local or broader scale (e.g. GALLO-ORSI, 2003).

Knowledge on population size and distribution of Cory's Shearwater, *Calonectris diomedea,* and Yelkouan Shearwater, *Puffinus yelkouan,* has improved within Italy in the course of the last decade only at a little extent, despite their high conservation value. Two national overviews dated c. 10 years apart (BRICHETTI *et alii*, 1992; BRICHETTI & FRACASSO, 2003) reported substantially the same data, except for slightly more precise information on minor colonies in the second report and a strongly decreased estimate for the Yelkouan Shearwater in Sardinia. The lack of new original information, leading to some sort of stagnation of knowledge (the same population estimates being indefinitely re-proposed in time), as well as the lack of island- or colony-based figures in the aforementioned overviews, are the main reasons for the present paper, which is functional to identify management strategies and conservation priorities for these two seabird species.

The black rat, *Rattus rattus,* is by far the most widespread terrestrial mammal on the Mediterranean islands. It has been introduced in the region by man two thousands years ago (AUDOIN-ROUZEAU & VIGNE, 1994; MASSETI, 2008) and its detrimental impact on nesting seabirds has been well documented in the last decades, at least at the local scale (e.g. DAYCARD & THIBAULT, 1990; THIBAULT, 1995; PERFETTI *et alii,* 2001; IGUAL *et alii,* 2006; PASCAL *et alii*, 2008; TRAVESET *et alii,* 2009). Among nesting seabirds, shearwaters are especially vulnerable to rat predation upon chicks and eggs (JONES *et alii*, 2008). Low impacts, however, have locally been assessed too (Ruffino *et alii,* 2008) and a region-wide analysis failed to identify the presence of rats as a factor conditioning shearwater distribution and numbers (Ruffino *et alii,* 2009).

We collected available population estimates and scattered breeding records of shearwaters in Italy, at a geographical detail sufficient for planning management strategies (particularly rat control and eradications) on the different islands. In addition, we performed *ad hoc* field surveys on some islands lacking adequate coverage, this representing the original part of our re-calculated totals. Geographic parameters, black rat distribution and data on breeding success were analyzed in order to understand present day distribution patterns. The operations of rat removal and control that were so far carried out on Italian islands occupied by shearwaters are reviewed.

Material and methods

The Italian ornithological literature was examined, searching for the most recent information on local breeding records and colony size of the two shearwater species. An island-based data bank, containing the best and most recent population estimates and information on the presence of black rats (and other predators) was created. The starting database included 308 islands identified from satellite images and personal experience; rocks lacking any form of vascular vegetation were not considered, as they are usually unsuitable for breeding shearwaters. Sites with unconfirmed or 'probable' breeding reports were not considered either. Islands where shearwaters are known to have bred in the last 150 years, but not at present, appear in Appendix 1 with a zero population size and a remark on local extinction. Abundances were in a few cases (noted with an appropriate mark in Appendix 1) attributed from vague original indications (e.g. 'several' pairs = 10-50) according to flexible criteria, depending on the topographical context and the writer's particular terminology. Colonies repeatedly surveyed in time, or with more than one population estimate available, were entered in the database with the most recent figures. Values expressed by ranges (min.-max., usually as a consequence of different assessing methods) were transformed into geometric means for analysis and map production, according to criteria adopted on large scale European assessments (cf Hagemeijer & Blair, 1997; BirdLife International, 2004). For the islands inhabited by shearwaters, the flat surface area and distances from the mainland and/or the nearest larger or comparable-sized island were calculated. The Yelkouan Shearwater and Cory's Shearwater are indicated hereafter by the acronyms YS and CS, respectively. The preliminary contents of our database data were previously made available to Bourgeois & Vidal (2008) for a global population assessment of YS, and used by Ruffino *et alii* (2009) for a broader scale analysis. Differences in local estimates between the present paper and those mentioned above are due to improved knowledge.

Results

With the only exception of three sectors of the Sardinian 'mainland' coast - Capo Caccia, Capo Figari and the Baunei cliffs - all the confirmed breeding records of the two shearwater species in Italy relate to small islands, sized from 0.36 ha of South Paduleddi islet (near La Maddalena, N Sardinia) to 8452 ha of Pantelleria island (cf dataset presented in Appendix 1). Very few of the smallest sized islands are occupied, despite their high number, and the proportion of occupancy increases with island size (Fig. 1). A total of only 64 islands out of 308 host (or hosted) at least one of the two shearwater species. From the sum of min./max. local abundances, the population size of Italy amounts to 3568-13212 YS pairs (sum of geometric means 6427) and 13344-21873 CS pairs (sum of geometric means 15807). The mainland-breeding fractions (Sardinia) of YS and CS amount, respectively, to 489 pairs (7.1% of the national total) and 701 pairs (4.4%).

Local extinctions were recorded just in a single, probable case for CS (Isola Rossa di Teulada in Sardinia, after 1901: cf Lilford 1875 and Bonomi 1901) and in at least two recent, confirmed cases for YS in

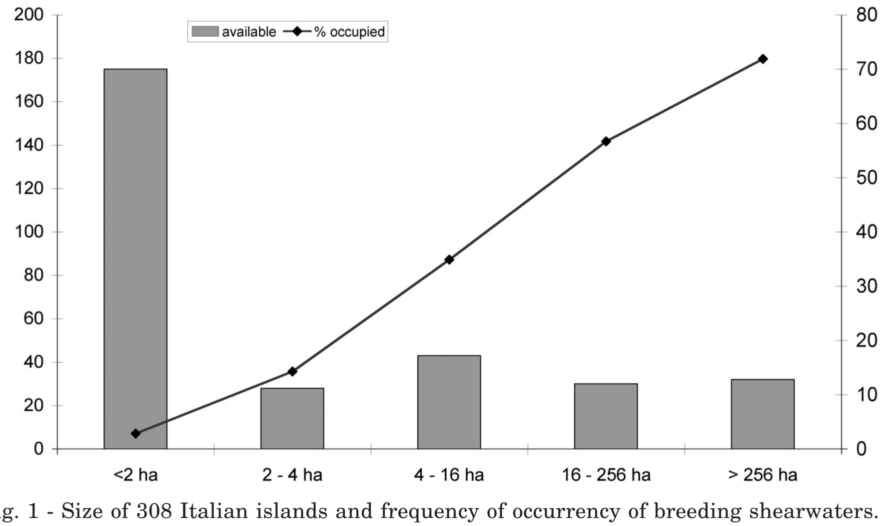

Fig. 1 - Size of 308 Italian islands and frequency of occurrency of breeding shearwaters. The most available size category (surface area <2 hectares) is nearly unexploited. Left y-axis: number of islands, right y-axis: shearwater occurrency (any species).

Tuscany: Pianosa after 1989 and Giannutri between 1993 and 2004 (see Appendix 1 for details). Moreover, local extinction of YS is possible on La Vacca and Cavoli islands in Sardinia, where night surveys are needed to confirm current absence of calling individuals. At Palmaria island in Liguria (not considered here for analysis and missing in Appendix 1), YS might have got extinct already in pre-historical times as only subfossil findings are known (BRICHETTI *et alii*, 1992). A careful search on this island in 2005-2007 gave negative results on present occurrence (M. Ferro and A. Peano, pers. comm.).

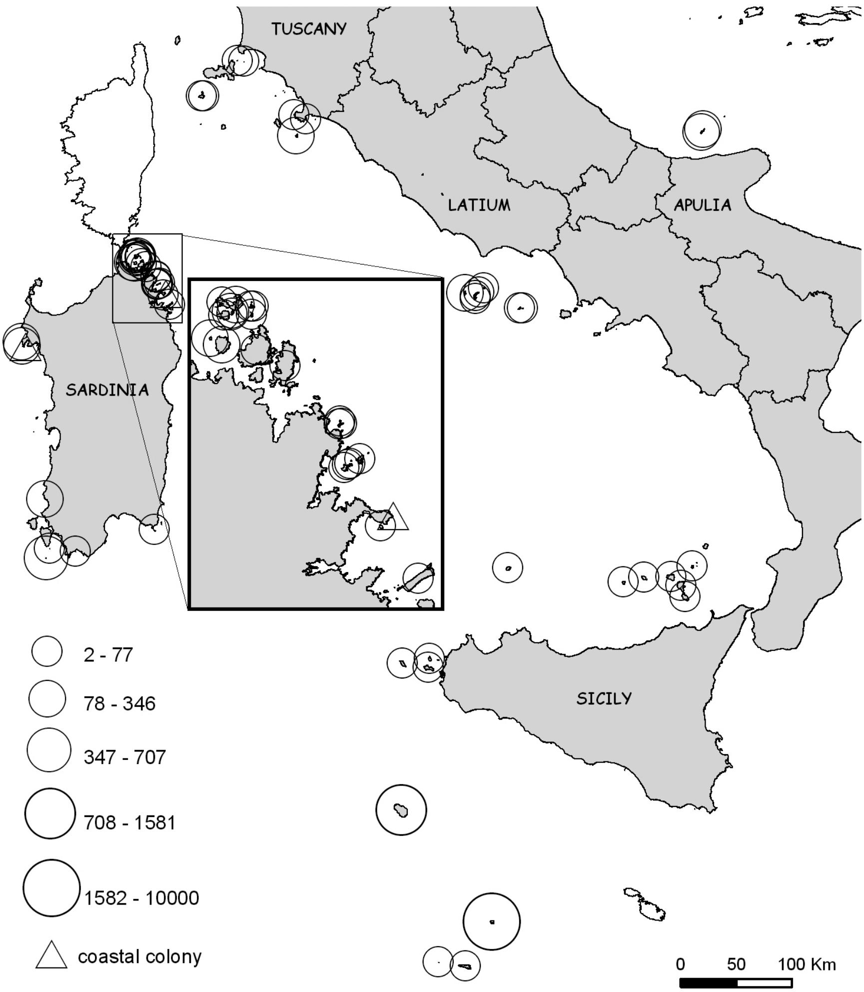

Fig. 2 - Distribution map of *Calonectris diomedea* in Italy. Circles: abundance on each island (number of pairs, expressed by the geometric mean of max./min. estimates). Triangles: location of the colonies on the Sardinian coast (irrespective of colony size).

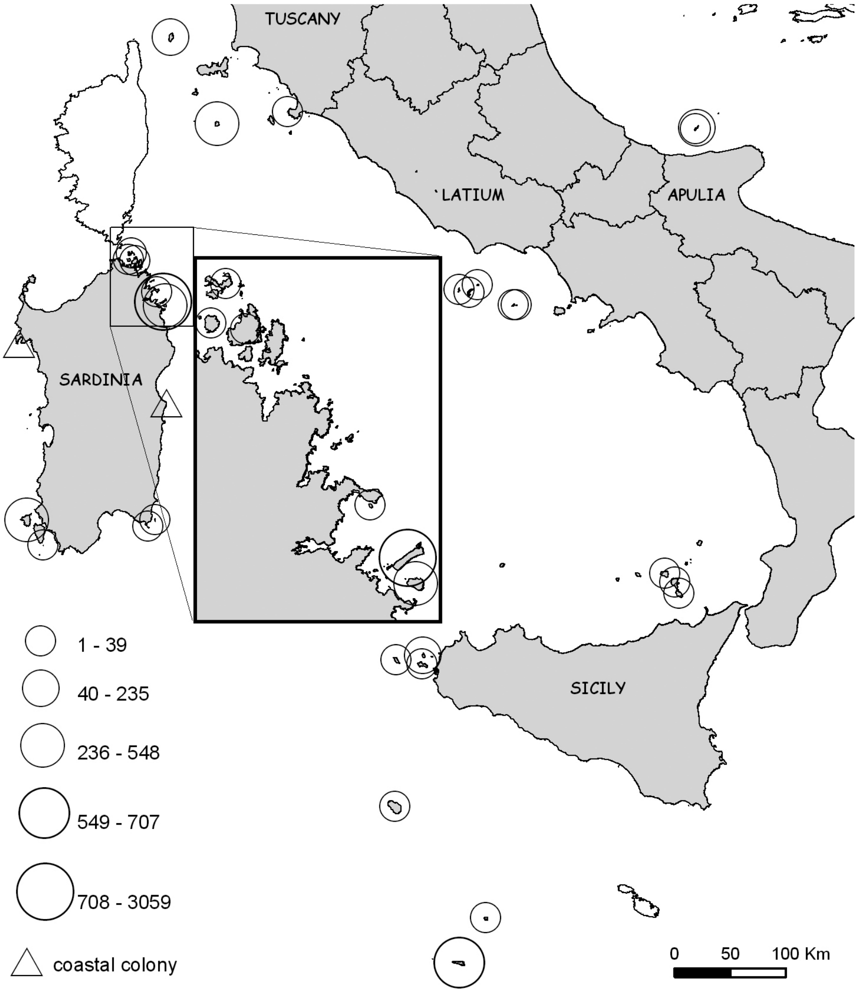

Fig. 3 - Distribution map of *Puffinus yelkouan* in Italy. Circles: abundance on each island (number of pairs, expressed by the geometric mean of max./min. estimates). Triangles: location of the colonies on the Sardinian coast (irrespective of colony size).

The distribution maps of the two species, based on our database contents, are shown in Figures 2 and 3. For YS, the largest population was confirmed to be that of the Tavolara-Molara-Figarolo island complex, with a new temptative estimate placed between 1510 pairs (preliminary extrapolation from densities of occupied burrows in 2006 and 2007 on the three islands) and 8500 pairs (corresponding to an evening count of c. 17,000 incoming birds at two convenient sea-watching stations in February 2008, i.e. just before egg-laying). For the largest CS colony (Linosa island), the figure of 10,000 pairs is re-proposed; it had been obtained in 1982 by capture-mark-recapture methods, by applying the

Lincoln index (MASSA & LO VALVO, 1986) on the "Mannarazza" colony, by far the largest on the island, but not the only one.

The number of islands inhabited by CS is just twice that of YS (58 vs 29, excluding mainland sites and Palmaria). The top sites for YS (Tavolara) and CS (Linosa) hold 48% and 63% of the respective national populations. The much higher number of islands hosting CS is paralleled by a prevalence of relatively small settlements and a clearly skewed distribution towards smaller-sized islands. Building the rank-abundance curves of the log-transformed island population size of the two shearwaters, the regression line is significantly steeper for YS (n= 29) than it is for CS (n= 58) (ANCOVA, homogeneity of slopes test, $F_{1, 84}$=9.94, P<0.003, Fig. 4).

Island use by the two species suggests a different mechanism of site selection. Within the subset of islands that hold shearwater colonies (n=64), the number of YS pairs positively correlated with island surface (Spearman's R= 0.60, P<0.00001) and distance from closest island or mainland (R_s= 0.37, P<0.003). No statistically significant relationship were found for the abundance of CS with either island area (P>0.81) or distance from closest island/mainland (P>0.64). There was a negative,

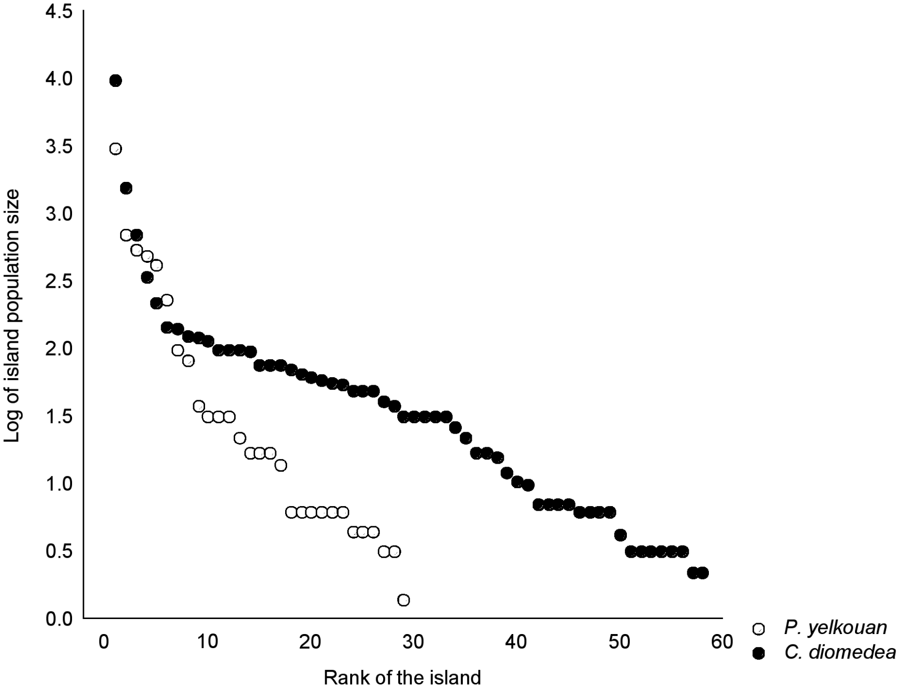

Fig 4 - Line plot showing the relation between log-transformed abundance of the two shearwaters and the rank of the islands. The regression line is significantly steeper for YS (n= 29) than it is for CS (n= 58) (ANCOVA, homogeneity of slopes test, P<0.003).

but not significant relationship between the numbers of pairs of the two shearwaters (R_s= –0.17, P= 0.18, n= 64). Islands with colonies of CS (n=58) have a smaller surface area and are closer to the mainland or other islands than those with colonies of YS (n=29) (Mann-Whitney U test: n=87, island area: adj. Z= 2.98, P<0.003; distance: adj. Z= 1.99, P<0.05) and islands hosting both species (n=23) are larger and more distant from mainland or other islands than those with colonies of one species only (n=41) (Mann-Whitney U test: n= 64, island area: adj. Z= –3.49, P<0.0005; distance: adj. Z= –2.00, P<0.05).

Only on six of the 64 islands is the black rat absent (Toro and Spargiotto in Sardinia, Lampione in Sicily and Argentarola, Cerboli, Palmaiola in Tuscany). These rat-free islands have a max. surface area of 13 ha (Toro) and are significantly smaller than rat-inhabited islands (Mann-Whitney U test: P<0.02, n= 64). Their distance from closest island or mainland ranges between 483 m (Argentarola) and 18 km (Lampione). Except for 1-2 YS pairs once found at Argentarola (0.02% of Italian population), rat-free islands are occupied by CS only (total: 759-1395 pairs; geometric mean: 1026, i.e. 6.5% of the Italian population). In two out of these six sites, rats have been present during the past 25 to 50 years and have naturally disappeared (Argentarola and Cerboli). Moreover, in order to improve the breeding success of shearwaters, projects of rat eradication were carried out on La Scola (1.6 h., treated in winter 2000-01 and again in 2005) and Giannutri (240 ha, winter 2005-06) in Tuscany and on Zannone (105 ha, winter 2006-07) in Latium (PERFETTI *et alii*, 2001; CAPIZZI *et alii,* 2007; SPOSIMO & BACCETTI, 2008; SPOSIMO *et alii*, 2008), with an additional benefit for 1.3% of the CS national population. Rat presence on islands that are not currently occupied by shearwaters is incompletely known, nevertheless the ratio with/without rats within the subsample of adequately assessed cases suggests that probably at least 85% of the 308 Italian islands host rats, the largest of the rat-free ones being Mal di Ventre in Sardinia (87.9 ha).

The consequence of rat eradication determined in CS a sudden and long lasting increase of productivity, from zero to 0.7-0.9 fledglings/pair, as shown by regular monitoring at La Scola (Fig. 5, cf also SPOSIMO & BACCETTI, 2008). Available information on the breeding success on some Italian islands is summarized in Table 1, where higher values are apparent for most rat-free islands and for islands where rats were even simply controlled within the colony, and not eradicated. The local control of rats within a colony site - but not in the rest of an island - has proven, therefore, to be highly beneficial, although on a temporary basis, and has been instrumental to later achieve a full eradication (cf. also CORBI *et alii,* 2005b for Zannone island, before the eradication project was launched). On Linosa, a local control of rats has been carried out in 2007-2008 in the “Mannarazza” main CS colony. Breeding success of 39.4% in 2006, before

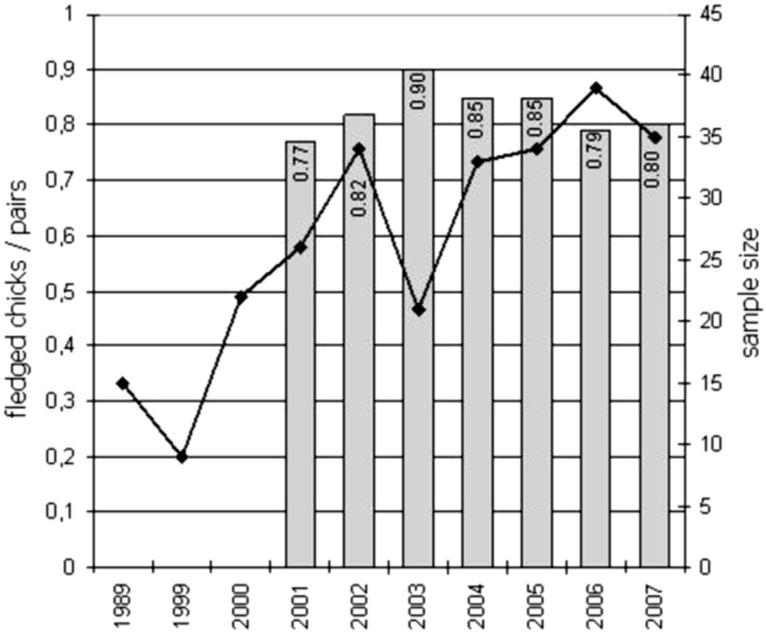

Fig 5 - Breeding success of *Calonectris diomedea* on La Scola island, Tuscany (bars, left y-axis). The line shows the number of burrows inspected twice per year (right y-axis). The first breeding season after rats were eradicated was that of 2001. Toxic baits were used again when rats returned in 2005.

Fig. 6 - Olive seeds regurgitated by Yellow-legged Gulls on La Vacca island and accumulated by black rats under boulders in a colony of *Calonectris diomedea*. Olive fruits are collected by gulls under plantations on the Sardinian mainland (photo: N. Baccetti, 2007).

the control started, increased in 2007 and 2008, after the rat control, to 89.3% (sample size: 150 nests) and 83.3% (sample size: 120 nests), respectively. The high breeding success in 2007 suggested to extend the rat control area and in 2008 it covered also the “Scasciati” colony, where many pairs of CS bred successfully (thick vegetation cover - including *Opuntia ficus-indica* and *Pistacia lentiscus* prevented to estimate the breeding success at this site). Not a single island holding YS had been treated up to the 2008 breeding season, despite this species is only present on rat-inhabited islands and it is heavily preyed upon by rats (e.g. 0% breeding success on Molara and 23% on Tavolara, cf Tab. 1), with all successful nests inside a few rat-free coastal caverns, i.e. in intra-island refuges *sensu* RUFFINO *et alii* (2009).

Tab. 1 - Breeding success of shearwaters in relation to presence or absence of *Rattus rattus*. Islands arranged according to surface area and species present (CS *Calonectris diomedea*, YS *Puffinus yelkouan*). Presence of *Rattus rattus* (N = absent, Y = present; C = locally controlled), number of fledged chicks/pair, number of sampled nests and other remarks are also given.

Island	Island area (ha)	Sp	Rat	Breeding success	N	Year/remarks	Reference
Argentarola (Tuscany)	1.2	CS	N	0:33	18	1999	PERFETTI *et alii* 2001, P. Sposimo & S. Romano, unpubl. data
				0.71	31	2000	
				0.86	21	2001	
La Scola (Tuscany)	1.8	CS	Y	0	15	1989 (11 years before rat eradication)	SPOSIMO & BACCETTI, 2008
		CS	Y	0	31	1999 (n= 9) and 2000 (n= 22): just before rat eradication, see Fig. 5 for subsequent variation	PERFETTI *et alii,* 2001
Cerboli (Tuscany)	8.8	CS	N	0.81	21	2000 (year with max. success)	PERFETTI *et alii,* 2001
		CS	N	0.47	15	2002 (year with min. success) overall mean 1999, 2000, 2002, 2007: 0.69, n= 67	P. Sposimo & F. Giannini unpubl. data
Zannone (Latium)	104	CS	Y	0	12	2003	CORBI *et alii,* 2005b, F. Corbi & F. Pinos, unpubl. data
			C	1:00	12	2004	
			C	0.93	14	2005	
			C	0.83	18	2006	
San Domino (Apulia)	208	CS	Y	0.85	?	data from 1988-90	BRICHETTI & FRACASSO, 2003
Linosa (Sicily)	545	CS	Y	0.39	231	2006	RANNISI *et alii,* 2008
			C	0.89	150	2007	B. Massa, unpubl. data
			C	0.83	120	2008	
Ponza (Latium)	750	CS	Y	0	8	2005	F. Corbi & F. Pinos, unpubl. data
			Y	0.63	27	2006	
			Y	0.50	20	2007	
			C	0.70	30	2008	
Molara (Sardinia)	347	YS	Y	0	18	2006	G. Spano & M. Putzu, unpubl. data
		YS	Y	0	7	2007	
Tavolara (Sardinia)	600	YS	Y	0	22	2007 top of the island and in caverns with rats	
		YS	N	0.78	9	2007 inside caverns inaccessible to rats	

Discussion

The insular breeding preference of shearwaters in Italy, as well as across the rest of the Mediterranean (ZOTIER *et alii,* 1999), has probably evolved in order to avoid terrestrial predators other than rats, which are not a natural component of the local fauna. The three 'mainland' colonies of Sardinia are lodged in vertical limestone cliffs with sea caves that are not accessible to any terrestrial mammal either. Breeding in similar locations has been hypothesized for Sicily too, although it was never confirmed (cf. discussion in BRICHETTI, 1980) and appears most unlikely.

The national estimate of 3568-13212 YS pairs (sum of geometric means 6427) is precedented by that of 11,000-18,000 by MESCHINI & FRUGIS (1993), overestimated according to BRICHETTI & FRACASSO (2003) who proposed 7000-14,000. The latter interval has also been accepted by BIRDLIFE INTERNATIONAL (2004) and BOURGEOIS & VIDAL (2008); the sum of local abundances listed by these authors, however, hardly reaches the lower limit of the proposed intervals. These variations are mainly caused by which figures are used for the Tavolara archipelago, where old Schenk's interval of 6000-9000 pairs, obtained back in 1978 (SCHENK & TORRE, 1986) and indefinitely reproposed in time (e.g. by referring it to 1995 in the first IBA enquiry: GARIBOLDI *et alii,* 2000), was replaced in later IBA grey literature (BRUNNER *et alii*, 2002) by the proposal of a new range of 1000-2000 pairs in 1992-2001, without any given motivation or methodological detail. The corresponding interval in our database, of 1510-8500 pairs, has been obtained from independent and recent data and reproposes higher values, but seems no less susceptible of further, major adjustments according to improved knowledge from ongoing monitoring.

Our national estimate, updated to 2003-2008 for over 60% of the population, suggests for the YS a marked decrease (-54%) from the first available figures of 1978-1985 (MESCHINI & FRUGIS, 1993). Previous overestimation had been suggested as a cause for recently decreasing the estimate (BRICHETTI & FRACASSO, 2003). However, vast abandoned sectors of Tavolara colonies, decreased raft sizes and a breeding success close to zero in most parts of the Tavolara archipelago suggest that a strong population decline could indeed have occurred, confirming the worst scenario of the 12-50% decrease proposed for the whole global range (BOURGEOIS & VIDAL, 2008).

The national total of 13,344 - 21,873 pairs of CS (sum of geometric means 15,807) is more in agreement with previous estimates of MESCHINI & FRUGIS (1993), BRICHETTI & FRACASSO (2003), SULTANA & BORG (2006) and BIRDLIFE INTERNATIONAL (2004), all reporting 15,000-18,000 pairs. This is mainly due to the fact that the estimate for the largest colony (Linosa, 63% of the Italian population) has remained unchanged since a couple of decades.

Data on breeding success seem to confirm that CS is more vulnerable to rats on small than on larger islands, as reported by MARTIN *et alii* (2000). This probably results from a higher predator density and/or higher prey vulnerability where nests are more concentrated and nest-site choice not as wide as on large islands (cf also RUFFINO *et alii*, 2009). Island selection by the two species and the respective number of occupied islands suggest, however, a greater vulnerability of YS when compared to CS, and the urgent need of conservation efforts. Only YS, breeding on a smaller number of islands (none of them rat-free), shows signs of population decline and definitely underwent to some local extinctions over the last decades (also in adjacent Corsica: BOURGEOIS & VIDAL, 2008). This is not surprising, considering that even the main colonies seem to be featured by a very low productivity rate, similar to that recorded for CS only at sites of secondary importance. What is surprising is rather the opposite, that heavily predated colonies have persisted until now, after many centuries of rat presence on most Mediterranean islands. To explain this apparent paradox (cf RUFFINO *et alii*, 2009), we suggest that rats, despite being present for many centuries, may have recently and diffusely increased in number, making predation episodes more frequent and impacting than earlier. The population increase and spread of the Yellow-legged Gull, *Larus michahellis,* (associated to habitat alterations: BEAUBRUN, 1994; VIDAL *et alii*, 1998; FOGGI *et alii,* 2000) represents the only large ecological novelty of the post-war decades on most islets within our study area, as well as across the rest of N Mediterranean (cf population data in THIBAULT & BONACCORSI, 1999; ARCAMONE *et alii*, 2001; CORBI *et alii,* 2005a; CADIOU *et alii,* 2004; BACCETTI *et alii*, 2008). Increasing food resources are being provided to rats by breeding gulls, either in the form of prey remains, pellets, dead chicks etc, or indirectly, favouring nitrophilous and/or invasive plant species that may also sustain large rat numbers (CASSAING *et alii,* 2005). Nearly the whole food delivered by gulls originates outside the island areas where rats are confined (e.g. from rubbish tips, fishing vessels and agriculture lands) and represents a reserve that rats can exploit also for several months after gull colonies have been deserted. A notable example of a long lasting crop is the huge number of olive seeds (Fig. 6), regurgitated on the bare rocks of most islands and steadily gnawed by rats over a long period, in order to exploit their carbohydrate- and fat-rich kernels (cf RINALDI *et alii*, 1994; CASELLI *et alii*, 1995). High site fidelity and adult survival, both being a life trait of many procellariids, would have eventually allowed shearwaters to cope with high nest predation and continue occupying their traditional colony sites until now, across a time span that has not exceeded the order of a few decades.

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Appendix 1 - Italian islands holding breeding shearwaters and Sardinian 'mainland' coasts where breeding has been documented (italic). Geographic data, presence of potential alien predators (r= black rat, c= feral cat, d=

Region	Site (Island)	Island area (ha)	distance from closest island or mainland (m)	closest island or mainland	man	alien predators	Puffinus yelkouan	Calonectris diomedea
Apulia	CAPRARA	49,5	320	San Nicola	s	r	-	100-160 (126.5)
Apulia	SAN DOMINO	208,6	298	San Nicola	p	r	30-50 (38.7)	200-240 (219.1)
Apulia	SAN NICOLA	46,2	320	Caprara	p	r	70-100 (83.7)	-
Latium	FARAGLIONE DI CALZONE MUTO	1,0	66	Ponza	n	none?	-	1-5 (2.2)
Latium	GAVI	18,1	136	Ponza	s	r	-	5-10 (7.1)
Latium	PALMAROLA	125,1	7300	Ponza	s	r, c?	10-30 (17.3)	100-150 (122.5)
Latium	PONZA	750,8	5700	Zannone	p	r, c, d	10-30 (17.3)	60-100 (77.5)
Latium	SANTO STEFANO PONZIANE	31,0	1400	Ventotene	s	r, c?	1-10 (3.2)	5-10 (7.1)
Latium	VENTOTENE	143,6	1500	S. Stefano	p	r, c	10-30 (17.3)	25-40 (31.6)
Latium	ZANNONE	104,7	5700	Ponza	n	r (erad.)	1-10 (3.2)	24-30 (26.8)
Sardinia (E)	*BAUNEI (coast)*	-	-	-	-	-	100-1000 (316.2)	-
Sardinia (E)	*CAPO FIGARI (coast)*	-	-	-	-	-	-	3-20 (7.8)
Sardinia (E)	FIGAROLO	22,1	368	mainland	n	r	10-100 (31.6)	30-100 (54.8)
Sardinia (E)	MOLARA	347,9	1400	Proratora	n	r	300-600 (424.3)	-
Sardinia (E)	TAVOLARA	602,0	1150	Reulino	p	r, c	1200-7800 (3059.4)	10-50 (22.4)
Sardinia (N)	BARRETTINI	10,3	712	Corcelli	n	r	-	50-100 (70.7)
Sardinia (N)	BUDELLI	171,8	240	Carpa	s	r, c	-	40-80 (56.6)
Sardinia (N)	CAMERE E	4,8	128	Camere W	n	r	-	40-60 (49.0)
Sardinia (N)	CAMERE W	3,6	86	Soffi	n	r	-	40-60 (49.0)
Sardinia (N)	CAPRERA	1581,8	0	Maddalena	p	r, c, p	-	* 20-200 (63.2)
Sardinia (N)	CARPA	0,4	193	Santa Maria	n	r	-	80-120 (98.0)
Sardinia (N)	CORCELLI	12,5	150	Piana di Corcelli	n	r	-	* 1-10 (3.2)
Sardinia (N)	MADDALENA	2014,6	0	Caprera	p	r, c, p, w	* 10-100a (31.6)	* 1-50b (7.1)
Sardinia (N)	MORTORIO	55,7	950	Camere E	n	r	-	40-60 (49.0)
Sardinia (N)	NIBANI EAST	3,5	5	Nibani W	n	r	-	1-10 (3.2)
Sardinia (N)	NIBANI NORTH	2,6	240	Nibani W	n	r	-	1-10 (3.2)
Sardinia (N)	NIBANI WEST	7,7	5	Nibani E	n	r	-	1-10 (3.2)
Sardinia (N)	PADULEDDI SOUTH	0,4	23	Paduleddi N	n	r	-	1-5 (2.2)
Sardinia (N)	PIANA DI CORCELLI	3,9	150	Corcelli	n	r	-	* 1-10 (3.2)
Sardinia (N)	RAZZOLI	164,3	70	Santa Maria	n	r, c	-	30-200 (77.5)
Sardinia (N)	SANTA MARIA	186,4	70	Razzoli	p	r, c	* 1-20 (4.5)	50-200 (100.0)
Sardinia (N)	SOFFI	44,7	80	Camere W	n	r	-	10-30 (17.3)
Sardinia (N)	SPARGI	421,9	1600	Maddalena	s	r, c, p	10-20 (14.1)	90-150 (116.2)
Sardinia (N)	SPARGIOTTO	10,1	685	Spargi	n	none	-	120-180 (147.0)
Sardinia (SE)	CAVOLI	42,1	708	mainland	n	r	* 1-20a (4.5)	5-30b (12.2)
Sardinia (SE)	SERPENTARA	31,3	3258	mainland	n	r	10-50 (22.4)	-
Sardinia (SW)	PAN DI ZUCCHERO	4,1	280	mainland	n	r	-	300-400 (346.4)
Sardinia (SW)	ROSSA DI TEULADA	10,5	693	mainland	n	r	-	* 1-50 (7.1)
Sardinia (SW)	SAN PIETRO	5089,2	3779	mainland	p	r, c, dog	500	-
Sardinia (SW)	TORO	13,4	7709	mainland	n	none	-	500-1000 (707.1)
Sardinia (SW)	VACCA	9,1	2838	mainland	n	r	* 1-20a (4.5)	5-50b (15.8)
Sardinia (W)	*CAPO CACCIA (coast)*	-	-	-	-	-	150-200 (173.2)	300-1600 (692.8)
Sardinia (W)	FORADADA	5,1	286	mainland	n	r	-	50-200 (100.0)
Sardinia (W)	PIANA DI ALGHERO	13,3	85	mainland	n	r	-	100-200 (141.4)
Sicily (N)	ALICUDI	509,0	15480	Filicudi	p	r	-	9-12 (10.4)
Sicily (N)	FAVIGNANA	2004,9	4040	Levanzo	p	r, c, d, h	2-20 (6.3)	20-50 (31.6)
Sicily (N)	FILICUDI	936,0	15480	Alicudi	p	r	-	2-20 (6.3)
Sicily (N)	LEVANZO	585,8	4040	Favignana	p	r	100	20-50 (31.6)
Sicily (N)	LIPARI	3766,4	890	Vulcano	p	r	2-20 (6.3)	2-20 (6.3)
Sicily (N)	MARETTIMO	1224,1	15860	Favignana	p	r	20-50 (31.6)	20-50 (31.6)
Sicily (N)	PANAREA	340,0	14054	Lipari	p	r	-	2-20 (6.3)
Sicily (N)	SALINA	2630,6	4370	Lipari	p	r	2-20 (6.3)	10
Sicily (N)	USTICA	825,5	53266	mainland	p	r	-	15-20 (17.3)
Sicily (N)	VULCANO	2119,5	890	Lipari	p	r	2-20 (6.3)	3-6 (4.2)
Sicily (S)	LAMPEDUSA	2059,6	43000	Linosa	p	r, c, d	500-1000 (707.1)	20-50 (31.6)
Sicily (S)	LAMPIONE	4,7	18000	Lampedusa	n	none	-	50-70 (59.2)
Sicily (S)	LINOSA	545,1	43000	Lampedusa	p	r	2-20 (6.3)	10000
Sicily (S)	PANTELLERIA	8452,3	70500	mainland	p	r, c, d	2-20 (6.3)	500-5000 (1581.1)
Tuscany	ARGENTAROLA	1,2	439	mainland	n	none	1-2 (1.4)	35-50 (41.8)
Tuscany	CAPRAIA	1926,6	27000	mainland	p	r, c, (d: erad.)	110-500 (234.5)	-
Tuscany	CERBOLI	8,8	6681	mainland	n	none	-	50-85 (65.2)
Tuscany	GIANNUTRI	239,5	11471	mainland	p	r (erad.)	extinct	50-200 (100.0)
Tuscany	ISOLOTTO D' ERCOLE	6,5	320	mainland	n	r (failed erad.)	-	1-10 (3.2)
Tuscany	LA SCOLA	1,6	242	Pianosa	n	r (erad.)	-	60-100 (77.5)
Tuscany	MONTECRISTO	1071,7	29410	Pianosa	p	r	400-750 (547.7)	-
Tuscany	PALMAIOLA	7,2	2950	Elba	n	r (erad.)	-	4-10 (6.3)
Tuscany	PIANOSA	1026,4	13300	Elba	p	r, c, h	extinct	30-50 (38.7)

feral dog, p= feral pigs or wild boars, w= weasel, h= hedgehog) and population estimates for both shearwater species (range, followed by geometric mean, * = only order of magnitude known), years of reference of the estimate.

year	sources
c. 2000	BRICHETTI & FRACASSO (2003): general estimates for the three islands: YS 100-150 pairs, CS 300-400 pairs; subdivision criteria: P. Brichetti pers. comm. Absence on fourth island (Pianosa) confirmed 2007 (G. Albanese, N. Baccetti, L. Melega)
c. 2000	BRICHETTI & FRACASSO (2003): general estimates for the three islands: YS 100-150 pairs, CS 300-400 pairs; subdivision criteria: P. Brichetti pers. comm. Absence on fourth island (Pianosa) confirmed 2007 (G. Albanese, N. Baccetti, L. Melega)
c. 2000	BRICHETTI & FRACASSO (2003): general estimates for the three islands: YS 100-150 pairs, CS 300-400 pairs; subdivision criteria: P. Brichetti pers. comm. Absence on fourth island (Pianosa) confirmed 2007 (G. Albanese, N. Baccetti, L. Melega)
2006	Own data (F. Corbi, F. Pinos, S. Francescato)
2005-2007	Own data (F. Corbi, F. Pinos, S. Francescato)
2005-2007	Own data (F. Corbi, F. Pinos)
2005-2007	Own data (F. Corbi, F. Pinos, S. Francescato)
2003-2004	Own data (F. Corbi, S. Francescato)
2005-2007	Own data (F. Corbi, F. Pinos, S. Francescato)
2005-2007	Own data (F. Corbi, F. Pinos, S. Francescato)
2006	Only this species has officially been given a confirmed breeding status (MESCHINI & FRUGIS, 1993; BRICHETTI & FRACASSO 2003). Population estimate suggested by an evening count of 1751 inds. from Punta Nera di Osalla in June 2006, cf. also ZENATELLO *et alii,* 2006; previous record: 31.03.1991, night calls heard at Portu Pedrosu by S. Nissardi and P.F. Murgia). CS probably breeding too (ZENATELLO *et alii,* 2006)
2008	Own data (N. Baccetti, M. Putzu, G. Spano).
2006	Own data (N. Baccetti, M. Zenatello)
2006-07	Own data (N. Baccetti, M. Putzu, G. Spano).
2003-2008	Own data (cf. text; upper limit after subtraction of the Molara and Figarolo populations)
1998	FOZZI *et alii,* (1998); [RABOUAM *et alii,* (1995): 33-150 pairs].
1998	FOZZI *et alii,* (1998)
1998	FOZZI *et alii,* (1998)
1998	FOZZI *et alii,* (1998)
1992	CESARACCIO & RACHELI (1993); traditional exploiting of CS eggs. On adjacent Porco isl., (fresh?) eggshell fragments at burrow entrances in April, species unknown (LILFORD, 1887).
1998	FOZZI *et alii* (1998); [RABOUAM *et alii* (1995): 16-40].
1995	RABOUAM *et alii* (1995)
(1992)	a FAVERO (1968): exact location of breeding site not mentioned, possibly not this island; no recent confirmation; b CESARACCIO & RACHELI (1993); FOZZI *et alii* (1993): confirmed breeding, no estimate given. Traditional exploiting of CS eggs reported by CESARACCIO & RACHELI (1993).
1991-1998	Own data (N. Baccetti); FOZZI *et alii* (1998): confirmed breeding, general estimate for all Arzachena islets 150-200 pairs.
1998	FOZZI *et alii* (1998): confirmed breeding, general estimate for all Arzachena islets 150-200 pairs. Apparently absent at present (own data, N. Baccetti & C. Azara, June 2008).
1998	FOZZI *et alii* (1998): confirmed breeding, general estimate for all Arzachena islets 150-200 pairs. Apparently absent on an incomplete survey in June 2008 (M. Putzu & M. Zenatello pers. comm.)
1998	FOZZI *et alii* (1998): confirmed breeding, general estimate for all Arzachena islets 150-200 pairs. Own data: N. Baccetti, 2 empty nests 11/11/1986; C. Azara, N. Baccetti, M. Putzu & M. Zenatello, 2 burrows not in use, apparently this species, June 2008, complete survey
1995	RABOUAM *et alii* (1995)
1995	RABOUAM *et alii* (1995)
1995	RABOUAM *et alii* (1995)
1995	RABOUAM *et alii* (1995)
1991-1998	Own data (N. Baccetti); FOZZI *et alii* (1998): confirmed breeding, general estimate for all Arzachena islets 150-200 pairs.
1998	FOZZI *et alii* (1998); [CESARACCIO & RACHELI (1993)]
1998	FOZZI *et alii* (1998); [RABOUAM *et alii* (1995): 50-100 pairs]
2007	a SCHENK & TORRE (1986): confirmed breeding record in 1976; MOCCI DEMARTIS (1986): questionable nest record in May 1982; apparently absent at present; b Own data (N. Baccetti, S. Nissardi, M. Zenatello), June 2007
2008	Large number of un-occupied, long abandoned burrows. Own data: N. Baccetti, Serpentara isl., June 2008; S. Nissardi & M. Zenatello, empty nests, apparently of Cory's Shearwater, on adjacent Varaglione Sud isl., June 2008
1997	Own data (N. Baccetti, S. Nissardi); [SCHENK & TORRE (1986)]
-	Breeding first recorded by LILFORD (1875); BONOMI (1901): occupied burrows in April 1900; recent incomplete surveys suggest possible extinction: 2008, own data (Baccetti, Nissardi, Zenatello)
1980	SCHENK & TORRE (1986)
2000	MARTIN *et alii* (2000); [SCHENK & TORRE, 1986: 300-400 pairs].
2007	a cf SCHENK & TORRE (1986), but breeding unlikely at present ; b Own data (N. Baccetti, M. Zenatello), June 2007; only previous report: LILFORD (1875), 12+ pairs
c. 2000	[SCHENK & TORRE (1986): 1500-2000 pairs], APLINGTON *et alii* (2000): CS 500-800 pairs, YS 150-200 pairs; both sources include Foradada isl. and Piana di Alghero isl. in their estimates (separated here)
2000-2005	cf remark under Capo Caccia; own data (N. Baccetti)
1985-2000	cf remark under Capo Caccia; own data (N. Baccetti)
2007	Own data (B. Massa, P. Lo Cascio)
2005	Own data (B. Massa)
2006	Own data (B. Massa, P. Lo Cascio)
2005	Own data (B. Massa)
2006	Own data (B. Massa, P. Lo Cascio)
2006	Own data (B. Massa)
2006	Own data (B. Massa, P. Lo Cascio)
2007	Own data (B. Massa, P. Lo Cascio)
2006	Own data (B. Massa)
2007	Own data (B. Massa, P. Lo Cascio)
2007	Own data (B. Massa)
2005	Own data (B. Massa, P. Lo Cascio)
2007	Own data (B. Massa); CS eggs traditionally exploited until recently
2005	Own data (B. Massa)
2001	Own data (N. Baccetti, P. Sposimo)
2008	Own data (N. Baccetti, P. Sposimo); [TELLINI FLORENZANO *et alii* (1997)].
2007	Own data (P. Sposimo)
2005-2007	YS: large colonies (TOSCHI, 1953), >50 calling inds. (1986, Baccetti own data), >5 occupied burrows (1988-1993: A. Massi, M. Ferro pers. comm.), no contacts (2005-07: P. Sposimo, N. Baccetti, own data). CS: (2005-07: P. Sposimo, N. Baccetti, own data)
c. 2005	M. Barlettani, pers. comm.
2007	Own data (N. Baccetti, P. Sposimo)
2007	A. De Faveri, B. Cursano, pers. comm.; [BACCETTI (1994): 50-250 pairs].
2001	Own data (N. Baccetti, P. Sposimo)
2007	Own data (N. Baccetti, P. Sposimo) [YS: BACCETTI, 1989]