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Rat eradications on Italian islands for the conservation of breeding seabirds

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ABSTRACT

A review of all the eradication projects involving *Rattus rattus* that have been carried out since 1999 on 14 Italian islands is presented. Data on different aspects related to the problem of rats on these islands are discussed, ranging from impact and benefit quantification, eradication methods and outcomes, to social problems such as lack of public awareness. A model aimed at identifying priority islands where eradication should be carried out was developed according to available budgets, an exercise that is worth extending throughout the Mediterranean.

INTRODUCTION

The problem of rat invasion on Mediterranean islands has particularly deep roots, mainly due to the early presence of man in the region (Audoin-Rouzeau & Vigne 1994, Ruffino *et al*. 2009). In a sample of 292 Mediterranean islands nearly all those larger than 20 hectares are occupied by the black rat *Rattus rattus* whereas the rate of presence is in the range of 40-70% on the islands belonging to smaller size classes (Ruffino *et al*. 2009). Within Italian islands, the situation is even worse; only four rat-free islands exist that are larger than 10ha (Baccetti *et al*. 2009), apart from a few larger ones where rats have recently been eradicated.

Heavy predation by rats, most often the black rat, on burrow-nesting seabirds has been widely documented worldwide (e.g. Hilton & Cuthbert 2010) and the Mediterranean is no exception, despite what may seem a paradox, that millennia of co-existence have not yet determined either the adaptation or extinction in bird populations (Ruffino *et al*. 2009). Although improving seabird productivity by rat removal may not represent a sufficient measure to balance adult mortality (Igual *et al*. 2009), urgent measures are needed to arrest such a widespread limiting factor, affecting the very start of demographic processes and featured by an unusually convenient attribute: that of being removable realistically, permanently and at affordable costs.

In this review we summarize the outcomes of all the eradication projects involving black rats that have been carried out with variable success since 1999 (Perfetti et al. 2001) on a total 14 Italian islands. Under this scenario, additional data on different aspects related to the problem of the impact of rats and their removal are discussed: i) predation by rats on Procellariiformes ('target species'); ii) the benefits for target (and non-target)

species by the removal of rats; iii) field techniques, bait delivery methods and costs; iv) the impact of rodenticides on non target species; v) re-invasions by rats after eradication; vi) and awareness and social problems. Furthermore, we developed a model aimed at identifying priority islands where eradication should be carried out according to available budgets, an exercise worthy of being extended throughout the Mediterranean. Most of these points, with the exception of the awareness problems, have been discussed more in detail by Capizzi *et al.* 2016).

RESULTS AND DISCUSSION

Rat eradication on Italian islands

With a couple of notable exceptions (Zannone and Molara islands: self-supported by local protected areas), all projects were usually supported by the EU LIFE tool. Details on all projects are presented in Table 1. Until 2005, when larger islands started being treated, bait stations were placed at a low density (4/ha), and especially until 2008, when aerial treatments came into use, these actions had a very modest contribution in terms of total surface area relieved from rat predation. The success of these early operations was usually low, due to re-colonization and inadequate evaluation of the consequences of the short distance from land (the exception was: La Scola, which will have to be treated repeatedly, see below). In the second half of the period, a similar fate was again encountered on two Sardinian islets, located 170-300 metres from land, and by a single failure (due to recolonization) on a large island, Molara (Sposimo *et al*. 2012). The outcomes of these activities can be seen in Figure 1 in terms of number of pairs relieved from rats: the failure at Molara had obvious consequences on the protected quota.

Rat predation on Procellariiformes

A re-assessment of the national population size and breeding distribution of two relatively widespread and vulnerable species (Scopoli's Shearwater *Calonectris diomedea* and Yelkouan Shearwater *Puffinus yelkouan*; Baccetti *et al*. 2009) revealed that Italian colonies are present on three coastal sectors of mainland Sardinia (all presumably including areas inaccessible to rats and other terrestrial predators) and, in particular, on 64 islands, 58 of which hosting the former species (6 of them rat-free, holding 6.5% of the total pairs) and 29 the latter (just one rat free, with irrelevant numbers): therefore, rats and shearwaters do indeed co-exist, but at a high cost. Studies on CS showed that in rat-free conditions productivity fell below 0.6 value only exceptionally, whereas whenever rats were present, it was usually zero (or a value below the detection possibility), only very occasionally – on relatively large islands – reaching the rat-free minima (Capizzi *et al*. 2015).

For Yelkouan Shearwater, where a single Italian island accounts for more than half of the known global population (Zenatello *et al*. 2012), chicks fledge in most years only in a few rat-free caverns, that are hardly relevant in terms of population (less than 1%). Factors explaining Ruffino's paradox (cf. Introduction, and Ruffino *et al*. 2009), such as periodical fluctuations of rat numbers, have probably been only partly identified and two additional possibilities can be recalled here. Despite early colonisations, present day black rat stocks may not be a thousand-years old: the populations of several Italian islands seem to have originated by a single, quite recent colonisation event, after the 'little ice age' centred on the 18th century (Colangelo *et al*. 2015). Moreover, their population size may have very recently increased to present levels, periodical rat extinctions becoming rarer, following the widespread increase of the Yellow-legged Gull *Larus michahellis*.

This species is responsible for the delivery of large amounts of exogenous food resources on many insular breeding sites, probably in all those where the shearwaters breed. This marked increase, largely man-dependent, represents the most obvious large-scale variation observed across the last 3-4 decades on nearly all the Italian islands. Food provided by gulls annually includes large amounts of olive stones that are dropped everywhere and last well beyond the breeding season (Baccetti *et al*. 2009). Their fat- and carbohydrate-rich kernels represents a high quality and durable food source for rats, to the point that gnawed olive stones are commonly used as a reliable indicator of rat presence/absence on islands.

Benefits from rat removal

Target species, in the Italian case Scopoli's Shearwater, Yelkouan Shearwater or both together, showed straightforward responses to rat eradications, as well as to rat control operations, albeit at a lesser extent (not shown). La Scola eradication of 2001 (Sposimo & Baccetti 2008), our earliest at an important Scopoli's Shearwater breeding site, can be taken as an example. It allowed productivity values passing from zero to constantly optimal values of 0.75-0.90 fledglings/pair in all years from 2001-2012, despite single rats that repeatedly returned and had to be eliminated. It also determined, after 10 years, a 2-fold local increase in the number of pairs, with current signs of levelling off at around 150-250 pairs, possibly caused by saturation of potential nests. Benefits extended to nearby Pianosa island, where pair numbers increased too despite the continued presence of rats; there is now proof of movements between the two islands from ring recoveries (one bird ringed on one island and recovered on the other and vice versa).

Recent eradication on Montecristo island in February 2012 (Sposimo 2014), and targeted at Yelkouan Shearwater, similarly brought productivity from a probable value of 0.12 in 2010 to 0.93-0.96 in the first two seasons after baiting (2012 and 2013, Gotti *et al*. 2014). As in the case of the eradication of Zembretta in Tunisia (Bourgeois *et al*. 2013), new nesting sites were occupied by prospectors immediately after the eradication, probably as an effect of increased attractiveness of very vocal, successful colonies: a foreign recruit from Provence was controlled in 2012, new sites contained breeders in 2013 and a set of 19 nest-boxes installed in autumn 2012 to facilitate future monitoring showed signs of visits right from the 2013 season, with one successful pair in 2014 and 2015 (Gotti *et al*. 2014 and unpubl.).

Field techniques, bait delivery and costs

Two basically different techniques were used (Table 1), bait stations (high-or low-density) or broadcast (hand or aerial). A detailed methodological description has been recently provided (Capizzi *et al*. 2015). The cost of the entire operations requiring delivery by helicopter was in the range of 270-343 € per hectare, comparable to using low density bait stations on relatively large islands (mean cost of the 2005-2007 land-based eradications: 400 € per hectare), and was less costly than treating very dispersed islets with high density stations (mean cost of the pre-2005 operations: 2,770€ per hectare). With the Montecristo eradication, our largest, the cost can also be expressed as c.800 € for protecting one of the existing Yelkouan Shearwater pairs.

Impact of rodenticides on non-target species

Our activities determined negligible impacts on the conservation of other animal species (cf. Capizzi *et al*. 2015, Gotti *et al*. 2014). Monitoring and field tests revealed the lack of any additive mortality in endemic invertebrates (e.g. Gastropods) and Amphibian larvae (*Discoglossus* tadpoles) that directly consumed baits. Only the Montecristo

operation, due to exceptionally dry weather that prolonged the pellets' life, caused a temporary population decrease in non-target bait consumers (wild goats introduced by man and mainly of historical value, and Yellow-legged Gulls whose numbers have been inflated by man too). Other bird species showed losses in the order of single individuals. Secondary poisoning, combined with the disappearance of rat stocks, determined local extinctions of tiny insular populations (at least on Giannutri and Molara) of the Barn Owl *Tyto alba*. This also raises the question of whether Barn Owls existed on the islands prior to their colonisation by rats. No positive impacts have been recorded on reptiles (geckos, lizards and snakes belonging to nine species).

Re-invasion by rats after eradication

Rat re-invasion was often recorded on islands closer than 500m to mainland or to other rat-infested islands, and in three cases it occurred more than once: La Scola (three times in a fifteen year period since 2001, i.e. in 2005, 2009 and 2011), Proratora and Cavalli (at least twice in the period 2008-2014). The case of Molara is different and more than 1000m offshore. Rats re-appeared there in 2010, two years after an otherwise successful aerial eradication, most probably due to a deliberate human intervention (Sposimo *et al*. 2012, Ragionieri *et al*. 2013), recalling 'recent genre fiction literature' (see e.g. Simberloff 2011).

Social/awareness problems

As the size of the operations increased, public concern also increased, usually expressed in the form of personal, negative comments on local forums in the web. A collection of some of these comments, often arrogant in tonality, but sometimes with good humour, showed the main reasons of concern 'being the waste of money' for trivial tasks or the suspect that projects are a pretext for diverting public money into private business. Second in line was the concern about human health (despite the fact the islands are un-inhabited) risks for non-target species and unknown consequences of toxic substances accumulated on such attractive islands that have been subtracted to tourism development in the name of nature conservation. Whatever the contents, disinformation or lack of awareness were the common cause of all perceived problems, nurtured by the fertile ground of typical Italian indifference to nature conservation issues, a well known plague that followed the humanistic orientation impressed into the school system and general culture since the Fascism times. Any effort to improve this situation obviously represents a challenge and a high priority for the future. Nevertheless, parallel to these personal and un-organized reactions was a less clear, but far more effective, feedback from animal-rights adherents, culminating into a legal regulation that currently forbids any aerial treatments, and in an (eventually unsuccessful) attempt of prosecuting the four representatives that had signed the partnership agreement of the 'Montecristo 2010' Life project. A between-ministry confrontation is currently the only hope for a change of the regulation and conserving Italian seabird colonies.

CONCLUSION

The expected benefits based on the shearwaters population size and distribution, compared to the costs and feasibility parameters, traced a clear way forward in selecting islands on which to carry out future rat eradications according to priority objectives thus avoiding a wrong resource allocation (Capizzi *et al*. 2009). Pending a solution of Italian internal problems, that at present do not allow putting in practice the most urgent concrete actions, a similar planning approach could perhaps be attempted on the Mediterranean scale, identifying priority islands in countries promising more positive attitudes.

Year	Season	Island	Area (ha)	Coordinates	Distance (m)	Method
1999 2000	winter	Peraiola	1	43°01'55"N-009°47'48"E	30	10 dispensers/ha with Brodicacoum and Bromadiolone baits
1999 2000	winter	Is. Topi	1.28	42°52'14"N-010°25'24"E	290	12 dispensers/ha with Brodicacoum and Bromadiolone baits
1999 2000	winter	Gemini Bassa	1.57	42°43'02"N-010°22'22"E	48	14 dispensers/ha with Brodicacoum and Bromadiolone baits
1999 2000	winter	Gemini Alta	1.86	42°43'06"N-010°22'27"E	120	13 dispensers/ha with Brodicacoum and Bromadiolone baits
1999 2000	winter	L'Isolotto	6.55	42°22'51"N-011°12'40"E	320	15 dispensers/ha with Brodicacoum and Bromadiolone baits
1999 2000	winter	Palmaiola	7.24	42°51'56"N-010°28'28"E	3000	11 dispensers/ha with Brodicacoum baits
2001	January April	La Scola	1.6	42°35'01"N-010°06'22"E	258	10 dispensers/ha with Brodicacoum baits
2006	February April	Giannutri	239	42°15'00"N-011°06'00"E	11500	4 dispensers/ha with Brodicacoum baits
2006 2008	winter	Zannone	105	40°58'09"N-013°03'21"E	4900	4 dispensers/ha with Brodicacoum baits
2008	October	Molara	348	40°52'06"N-009°43'48""E	1460	aerial delivery, 12kg/ha Brodifacum pellets
2008 2010	October	Proratora	4	40°50'47"N-009°43'23"E	173	hand broadcast and 16 dispensers/ha with Brodicacoum baits
2009 2010	winter	Piana	13.62	40°53'17"N-009°39'04"E	645	16 dispensers/ha with Brodicacoum baits
2009 2010	winter	Cavalli	2.22	40°53'08"N-009°38'25"E	300	16 dispensers/ha with Brodicacoum baits
2012	January February	Montecristo	1072	42°19'51"N-010°18'37"E	29500	erial delivery, 10,5kg/ha Brodifacum pellets

Table 1. An overview of black rat *Rattus rattus* eradications from Italian islands

Success	Funded	Reference
Re-invaded	LIFE97 NAT/IT/004153 (LIFE Capraia)	Perfetti *et al.* (2001)
Re-invaded	LIFE97 NAT/IT/004153 (LIFE Capraia)	Perfetti *et al.* (2001)
Probably Re-invaded	LIFE97 NAT/IT/004153 (LIFE Capraia)	Perfetti *et al.* (2001)
Probably Re-invaded	LIFE97 NAT/IT/004153 (LIFE Capraia)	Perfetti *et al.* (2001)
Re-invaded	LIFE97 NAT/IT/004153 (LIFE Capraia)	Perfetti *et al.* (2001)
Re-invaded Eradicated	LIFE97 NAT/IT/004153 (LIFE Capraia)	Perfetti *et al.* (2001)
Eradicated repeatedly	LIFE97 NAT/IT/004153 (LIFE Capraia)	Sposimo & Baccetti (2008)
Eradicated	LIFE04 NAT/IT/000172 (Iso Tosca)	Sposimo *et al.* (2008)
Eradicated	Circeo National Park	Francescato *et al.* (2010)
Re-invaded	MPA Tavolara and Regione Sarda	Sposimo *et al.* (2012)
Eradicated repeatedly	MPA Tavolara and Regione Sarda	Sposimo *et al.* (2012)
Eradicated	MPA Tavolara and Regione Sarda	Sposimo *et al.* (2012)
Eradicated repeatedly	MPA Tavolara and Regione Sarda	Sposimo *et al.* (2012)
Eradicated	LIFE08 NAT/IT/000353 (Montecristo 2010)	Sposimo (2014)

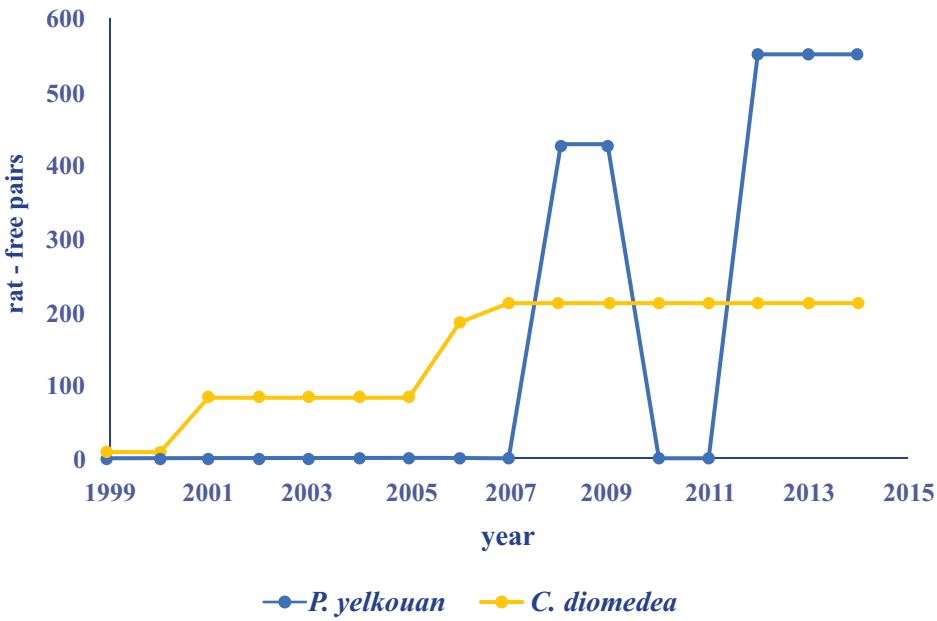

Figure 1. Cumulated fractions of seabird populations relieved from black rat *Rattus rattus* predation on Italian islands. Each island has been considered with the respective, pre-eradication number of pairs, without accounting for subsequent local increases (from Capizzi *et al.* 2015).

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