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# Impact of predation by the Black Rat *Rattus rattus* on the breeding success of Cory's Shearwater *Calonectris diomedea* on Linosa island (Sicily, Italy)

*Effekten av svartråttans* Rattus rattus *predation på gulnäbbade lirans* Calonectris diomedea *häckningsframgång på Linosaön (Sicilien, Italien)*

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**Abstract**

We studied the impact of predation by the Black Rat on the breeding success of Cory's Shearwaters on Linosa island (Pelagian archipelago) in 2006. Between 6 and 10 June we marked 231 active nests, which we checked in July, September and October. In July we found eggs or pulli in only 121 nests, while in the remaining 110 we found: 4 abandoned eggs, 1 crushed egg, 80 predated eggs, and 23 predated chicks; in two cases adults were present without eggs or chicks. In September we found 91 eggs or chicks, while 30 were predated by rats. In October no rat predation was observed. The reproductive success was 39%, rat predation being 59% and natural losses 2%, but long-term studies are needed to better quantify the exact effects of rat predation on Linosa's shearwater population.

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## Introduction

Introduced and invasive predators have been the main cause of extinction for numerous species of birds breeding on islands (Moors & Atkinson 1994, Whittaker 1998, Blackburn et al. 2004) and are the most important threat for pelagic bird species such as shearwaters and petrels (Imber 1978), which are characterized by a long life cycle (Owens & Bennet 2000).

Among predators, the Black Rat *Rattus rattus*, an omnivorous (Caut et al. 2007), although also a vegetarian species (Cheylan 1984), is responsible for the extinction of various species of seabirds on small islands (Daycard & Thibault 1990, Martin et al. 2000, Andreotti et al. 2001).

Seabirds have evolved to breed in sites where terrestrial predators do not exist (Lack 1968). For some prey species, rat predation is a relatively recent phenomenon; as such, these species have not yet developed appropriate behaviours against this predator (Igual et al. 2006), although on the island of Lavezzi Black Rats and Cory's Shearwaters have coexisted at least since the 14th century (Vigne et al. 1991).

The Black Rat is one of the most common species on Mediterranean islands; it is found on all of the large and medium-sized islands, and on many of the smallest ones as well (Perfetti et al. 2001). Introduced rats (both *Rattus rattus* and *R. norvegicus*) strongly affect seabirds, reducing their populations and in some cases causing their extinction (Atkinson 1985, Moors et al. 1992, Martin et al. 2000). Black Rat colonization generally has anthropic origins, though small islands close to the mainland can be colonized spontaneously by swimming rats (Palmer & Pons 2001).

In many islands, especially on small rocky islands (Martin et al. 2000), it has been proven that rats greatly decrease the breeding success of four species of seabirds: Cory's Shearwater *Calonectris diomedea*, Great Shearwater *Puffinus gravis*, Yelkouan Shearwater *Puffinus yelkouan*, Storm-petrel *Hydrobates pelagicus* (Imber 1978, Thibault 1995, Penloup et al. 1997, Amengual & Aguilar 1998, Vidal & Zotier 1998).

For this reason, in the last several years there have been multiple attempts to eradicate Black Rats from some Mediterranean islands (Thibault 1992, 1995, Perfetti et al. 2001, Corbi et al. 2005). Modern techniques such as stable isotope analysis (Hobson et al. 1999, Stapp 2002) have confirmed

that rats feed on seabirds, suggesting that previous studies on rat stomach contents underestimated the importance of seabirds in their diet. Since the 1980s, methods to control and eradicate rat populations on medium-sized islands have been perfected (Taylor et al. 2000).

On Linosa, the Black Rat was introduced by man and its density is not evaluable at present. It occupies the entire island, particularly rocky areas next to the sea (Massa pers. comm.).

Like other Procellariiformes, Cory's Shearwater is highly vulnerable due to its delayed maturity, since it lays one egg per year, and because of its long reproductive cycle, from April to October (Cramp & Simmons 1977).

Cory's Shearwater is strongly decreasing throughout its range, particularly in the Mediterranean, where the endemic nominate subspecies breeds. It is included in Annex 1 of EU Directive n.79/409 (the so called "Birds Directive"), it is assessed as a SPEC 2 species (Species of European Conservation Concern; Tucker & Heath 1994, BirdLife International 2004) because it has "unfavourable conservation status in Europe and its global population is concentrated in Europe", and it is listed as vulnerable in the IUCN European Red List (Baille et al. 2004).

Linosa island hosts the largest breeding colony of this species in Italy (estimated at 10,000–15,000 pairs; Iapichino & Massa 1989), and the second largest colony in the west-central Mediterranean (Granadeiro et al. 1997).

As part of its efforts to protect threatened species of wild fauna, in 2006 LIPU (Italian League for the Protection of Birds) in collaboration with the Stazione d'Inanellamento of Palermo, began a study to improve our knowledge of the biology of Cory's Shearwaters on Linosa, and to determine the impact of the different threats to the breeding colony.

Possible causes of the reduced breeding success of the colony include the following: (i) Human egg-collecting. Iapichino in Massa (1985), Iapichino & Massa (1989), and Massa (1985) considered this to be the main cause for the colony's decline, with up to 4000 eggs being collected yearly. Over the last several years egg-collecting has declined and is now less pervasive. (ii) Rat predation of eggs and chicks. (iii) Predation by other introduced mammals (cats and dogs) on chicks, adults and fledglings. (iv) Loss of habitat because of increasing human activities and new buildings. (v) Accidental mortality caused by longline-fishing.

In 2006 human eggs collecting for food purposes on Linosa was considered insignificant as a result of (i) fear that eggs could be vectors of avian flu, (ii) Lipu's education efforts to stop the population from collecting eggs, along with enforcement activities by Forestry officials, and (iii) involvement of several islanders, who were very familiar with the colony, in the project activities. The aim of this work was to verify for the first time the limiting factors influencing breeding success in the Cory's Shearwater breeding colony on the island of Linosa, with special attention to the impact of Black Rats.

## Material and methods

Linosa island (35°52'N, 12°52'E) is part of the Pelagie Islands, an archipelago located in the Sicilian Channel. The island, of volcanic origin, has an almost circular shape with a maximum diameter of 3.5 km, 11 km of coastal perimeter and a surface of 5.4 km$^2$. Linosa is an Important Bird Area (IBA, 168), Special Protection Area (SPA, ITA040013) and Site of Community Importance (SCI, ITA040001). Since 2000 it is a Nature Reserve of the Sicilian Region managed by the Azienda Foreste Demaniali.

Cory's Shearwater nests throughout the island, with the exception of the village located in the south. The nests can be found under vegetation, under rocks or in inaccessible large caves in the volcanic rock, where several tens of pairs can nest (Massa et al.1988).

The study was carried out throughout the breeding cycle of the Cory's Shearwater colony: (i) arrival at the colony (March–April), (ii) egg laying (May–June), (iii) hatching (July), (iv) feeding of chicks (July–October), and (v) fledging (October). The field work was conducted by one or two researchers during a total of 64 days, broken down into the following periods: 20–28 April, 18 May–11 June, 21–31 July, 1–10 September, and 11–19 October 2006.

In April we selected a study site (c. 10 ha) that was accessible and had high nest density, an area called Mannarazza located in the northwestern part of the island. Farthest from the sea, it was covered by dense vegetation, mostly *Pistacia lentiscus, Euforbia dendroides, Periploca angustifolia, Opuntia ficus-indica*. Closer to the shoreline, there was an area with isolated bushes of *Lycium intricatum, Periploca angustifolia, Limonium algusae*. In the immediate vicinity of the sea, vegetation was completely absent. The highest nest densities were found in the areas with isolated bushes located close to the sea, in agreement with previous stud-

Figure 1. The breeding habitat of Cory's Shearwater on Linosa island. Upper photo: Overview of the main breeding area in the northwest of the island. The birds breed both in the bare rocks nearest to the seashore and in the abandoned cultivated area where rich Mediterranean vegetation is growing. Lower left: Monte rosso. Nests can be found in abundance even in the inner areas away from the coast. Lower right: the Mannarazza area, our selected study site. The area is also a Regional Environmental Reserve, and the path seen in the photo crosses all the reserve.
*Översikt av gulnäbbade lirans häckningsbiotop på Linosaön. Upptill: översikt av häckningsbiotopen i den nordvästra delen av ön. Lirorna häckade både i klipporna nära kusten och i det övergivna jordbruksområdet som övertagits av rik mediterran vegetation. Nedtill vänster: Monto rosso. Bon påträffas talrikt även i öns inre delar. Nedtill höger: vårt studieområde Mannarazza, som också är ett regionalt naturreservat. Stigen på bilden korsar hela reservatet.*

ies on Cory's Shearwater (Massa et al. 1985, Massa ined.); these areas were richest in caves, cavities, and holes. Figure 1 shows the habitats of the study area.

For logistical reasons, we divided the area into three sub-areas (sub-area A-B-C). When all birds were incubating, we recorded the position of the nests with a GPS (Garmin, mod. eTrex-Vista, WGS84 system).

Instances of Black Rat egg predation were classified as such when gnawed egg shell remnants were found inside or near the nests. Chick predation was classified as such when (i) the nest was empty, (ii) down was present inside the nest, (iii) internal membrane remnants were present inside the nest, or (iv) chicks were absent from where hatching was recorded previously.

We excluded other potential predators such as dogs or cats for the following reasons. Dogs were never recorded in the three sub-areas because they are kept near the houses and there are no stray dogs on the island. Though we saw cats in the colony area, we never found evidence of their predation either on eggs or on chicks. The ground inside the nests is covered by a thin layer of soft sand and cat tracks were never recorded, while rat tracks and excreta were found where eggs or chicks were predated. Cats holding or eating chicks were never seen. The predated chicks found outside the nests were whole and showed predation tracks only on the nape, clearly having been predated by rats.

Moreover, preliminary data from the second year of monitoring, after rat control efforts were launched, seems to confirm a significant decrease of rat predation on chicks and consequently a very high density of chicks. Rabbits are the only other mammals present on the island.

We also exclude gull predation because eggs and chicks are located too deep in the burrows to be accessible for gulls; broken eggs found inside or near nests showed rat jaw marks. Moreover, the Yellow-legged Gulls *Larus michaellis* breeding in a small colony on the opposite side of Linosa leave the island in July before the shearwaters hatch.

To verify Black Rat predation, we monitored nests periodically in July (hatching and to register losses), September (grown chicks and to register losses) and October (fledglings). We chose to begin the study on Black Rat predation on 6 June because Cory's Shearwater eggs laid during the last decade of May were already incubated and consequently of no interest for egg collecting, one of the major impacts recorded in the past. We could thus be sure that any missing eggs were to be attributed to Black Rat predation. The first control visit took place between 20 and 30 July, the second between 1 and 10 September, and the third between 11 and 19 October.

During the period from April to September, visits to the colony took place mostly in the early morning, from 7 to 11 a.m. and in the late afternoon, from 5p.m. till dusk. Night visits generally took place at sunset (in moonless conditions), when birds came back to land.

For statistical analysis we used contingency tables and $\chi^2$ tests.

## Results

In the period 6–10 June 2006, in the three sub-areas together, we found and mapped 231 Cory's Shearwater eggs, 60 in sub-area A, 112 in B, and 59 in C (Table 1).

In July we found 121 eggs or pulli, 4 abandoned eggs, 1 deformed egg, 80 predated eggs, and 23 predated chicks; in two cases adults were present without eggs or chicks (Table 1). Several egg shells were found near the nests, often out in the open and showing clear rat jaw marks. Egg shells were found on the ground, inside nests, out in the open on rocks or in *Lycium intricatum* bushes. Rat predation on shearwater eggs was not statistically different in the three areas (Contingency table, $Chi^2 = 5.69$, $df = 4$, $P = 0.15$), while predation was significantly higher on eggs than on chicks ($Chi^2 = 31.5$, $df = 1$, $P<0.001$).

In September, 91 of the 121 nests that were active in July still had eggs or chicks, while 30 had been predated (Table 1). In twenty of the predated nests chicks had been present in July. In the other ten predated nests eggs had been present in July, but it was not possible to determine whether it was the chick (most likely) or the egg that had been predated.

There was no additional rat predation in October, due to the large size of the chicks. Therefore, reproductive success was 39%, rat predation (or overall mammal predation, allowing for the possibility of some predation by cats) was 59%, and natural losses 2%, indicated by the 4 abandoned eggs and 1 crushed egg that we found.

## Discussion

Black Rat predation was the most important factor affecting the breeding performance of Cory's Shearwaters on Linosa. Monitoring efforts began at the start of the incubation period, when it was cer-

Table 1. Rat predation on Cory's Shearwater on Linosa island in 2006.
*Råttpredation på gulnäbbad lira på Linosaön 2006.*

| | 6–10 June | 20–30 July | | | | | | | 1–10 September | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Successful *Lyckade* | | | Losses *Förlorade* | | | | Alive | Predated *Rövat* | |
| Areas *Område* | Egg *Ägg* | Chick *Unge* | Ad+chick *Ad+unge* | Ad+egg *Ad+ägg* | Aband. *Överg.* | Damaged *Skadat* | Predated *Rövat* | Ad+0 *Ad+0* | Chick *Unge* | Chick *Unge* | Egg/chick *Ägg/unge* |
| A | 60 | 31 | 2 | 1 | 0 | 0 | 26 | 0 | 26 | 7 | 1 |
| B | 112 | 50 | 3 | 5 | 3 | 0 | 50 | 1 | 41 | 12 | 5 |
| C | 59 | 24 | 0 | 5 | 1 | 1 | 27 | 1 | 24 | 1 | 4 |
| A+B+C | 231 | 105 | 5 | 11 | 4 | 1 | 103 | 2 | 91 | 20 | 10 |
| % progr-essively | | 100*(105+5+11)/231= 52% successful lyckade | | | 100*(4+1+103+2)/231= 48% losses förlorade | | | | 39% successful | 61% losses | |

Legends to column headings
*Förklaringar till kolumnrubrikerna*

| | |
|---|---|
| Egg<br>*Ägg* | Number of individual or multiple caves with egg on 6 June.<br>*Antal individuella eller multipla hålor med ägg 6 juni.* |
| Chick<br>*Unge* | Lone chick, without adult/s.<br>*Ensam unge utan adult.* |
| Ad+chick<br>*Ad+unge* | Adult with young chick (several days old).<br>*Adult med liten unge (flera dagar gammal).* |
| Ad+egg<br>*Ad+ägg* | Adult incubating.<br>*Adult ruvande.* |
| Aband.<br>*Överg.* | Abandoned egg near the nest, cold or without adults, checked repeatedly and always without adult.<br>*Övergivet ägg nära boet, kallt eller utan adult, kollat flera gånger och alltid utan adult.* |
| Damaged<br>*Skadat* | Deformed egg having one half damaged, the other half whole.<br>*Deformerat ägg med ena halvan skadad, andra halvan hel.* |
| Predated<br>*Rövat* | Empty nest. Some nests seemed long abandoned; presumably the egg was predated immediately after being laid. Down was found in other nests, presumably indicating predation on a downy chick. Although we recorded these separately, they are reported together here since our assumptions cannot be proven.<br>*Övergivet bo. Somliga bon föreföll övergivna sedan länge; förmodligen rövat omedelbart efter värpningen. I andra bon påträffades dun, förmodligen tecken på predation av dununge. Fastän vi registrerade dessa tecken separat, rapporteras de tillsammans eftersom vi inte kunde vara säkra.* |
| Ad+0<br>*Ad+0t* | Adult without egg or chick. Data useful to estimate number of adults on land during the day.<br>*Adult utan ägg eller unge. Uppgift värdefull för att beräkna antalet adulta på land dagtid.* |
| Chick alive (September)<br>*Unge vid liv i (september)* | Large chicks, 40–50 days old. We assume that the rate of rat predation in September/October diminishes greatly, although we photographed a large, feathered chick laying half-devoured just outside the nest. In large chicks, only the skull is usually devoured, probably because the rest of the body is too rich in fat.<br>*Stor unge, 40–50 dagar gammal. Vi antar att råttpredationen i september/oktober minskat kraftigt trots att vi fotograferade en stor, befjädrad unge som låg halvt uppäten just utanför boet. På stora ungar äts vanligen bara huvudet, troligen för att resten av kroppen är för fettrik.* |
| Chick (Sept)<br>*Unge (sept)* | Indicates predation on a chick that was alive during the previous visit.<br>*Indikerar predation på unge som levde vid föregående kontroll.* |
| Egg/chick<br>*Ägg/unge* | Indicates predation on an egg or a chick in a nest where the adult was incubating during our previous visit.<br>*Indikerar predation på ett ägg eller en unge i ett bo där adult ruvade vid föregående kontroll.* |

tain that no islanders would collect eggs. Predation by other mammals, such as cats, has been recorded during the breeding season on *Puffinus yelkouan* in the Hyéres islands, where more than 400 birds were predated each year (Bourgeois & Vidal 2005). However, in our study we were able exclude predation by other animals than black rats.

Thibault (1995) reports that rat predation on chicks in Corsica takes place during the first days of July, particularly during hot and dry summers (Moors et al. 1992). According to the literature, chicks are mostly predated in their first few days of life, particularly between the second and seventh day after hatching (Igual et al. 2005), when both parents leave the colony in search of food. Although we were not able to determine exactly at which age each predated chick was killed on Linosa, our results also suggest that most predation occurred early. We recorded most predation during the second decade of July, only little predation later on, and none at all when the young approached fledging. Igual et al. (2006) state that rat predation affects chicks more than eggs, and that predation on the latter concerns abandoned or broken ones, the period of chick predation frequently corresponding with low vegetation productivity (Thibault 1995), when the rats presumably are not able to sustain themselves on their normal vegetarian food alone. Also on Linosa the vegetation productivity in summer is poor, but the rat predation pattern was the opposite one, higher on eggs than on chicks.

Since there are no rat-free large or medium-sized Mediterranean islands (Cheylan 1984, Aguilar & Amengual 1998, Perfetti et al. 2001), the Stazione d'Inanellamento of Palermo, in collaboration with LIPU (Italian League for the Protection of Birds), began in 2007 a campaign to control the Black Rat population on the island of Linosa, which is classified as a medium-sized island (Massa ined).

Rat eradication efforts on 16 Mediterranean islands have had a success rate close to 90% (Thibault 1992, Amengual & Aguilar 1998, Orueta & Aranda 1998, Vidal & Zotier 2000). The best examples are the particularly encouraging results obtained on the islands of Zannone and Scola in Italy. On Zannone in the Pontine archipelago, Black Rat eradication led to full breeding success (100%) for the local Cory's Shearwater colony, reversing the previous complete breeding failure (Corbi et al. 2005). On Scola in the Tuscan archipelago (1.5 ha), the entire colony of Cory's Shearwaters (about 80–100 pairs) was predated by rats. Subsequent rat control allowed the colony to achieve good reproductive success (85%) (Sposimo et al. ined., Perfetti et al. 2001).

The breeding success of Cory's Shearwaters on Linosa was very low in 2006, only 39%, compared with most other Mediterranean islands, where it varies between 40 and 80% (Cramp & Simmons 1977). However, from our one year study we cannot tell whether 39% is an average or exceptional value for Linosa. According to Thibault (1995) rat density on medium-sized islands shows annual variations and it could be that rat density was high in 2006 and this year could have been an aberrant year in Linosa island. On medium-sized islands such as Linosa, the impact of rat predation should conflict less with shearwater population dynamics and should not constitute an actual threat for the survival of the breeding colony (Thibault 1995). But if 39% predation is an average value for Linosa the rat population reduction experiment ought to improve the breeding conditions significantly.

Our study suggests that Black Rat predation is currently the main cause of breeding failure in the Cory's Shearwater colony on Linosa, but long-term studies are necessary to better quantify the exact effects of rat predation. Rats are widespread throughout the island, and many islanders use rat poison in order to control their population in the village, thus protecting both their food supplies and their domestic fowl, which are sometimes killed by rats.

For Cory's Shearwater, as well as for other seabirds that could colonize the island of Linosa in the future, the control or the eradication of Black Rats should lead to improved breeding success, as was the case on other small Mediterranean islands (Brooke 1990, Daycard & Thibault 1990, Martin et al. 2000, Andreotti et al. 2001), because high rat densities certainly represent a threat to Cory's Shearwater colonies.

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## References


Andreotti, A., Baccetti, N., Perfetti, L., Besa, M., Genovesi, P. & Guberti V. 2001. Mammiferi e Uccelli esotici in Italia: analisi del fenomeno, impatto sulla biodiversità e linee guida gestionali. *Quaderno Conservazione Natura*, 2, Min. Ambiente – Istituto Naz. Fauna Selvatica.

Amengual, J.F. & Aguilar, J.S. 1998. The impact of the Black rat *Rattus rattus* on the reproduction of Cory's Shaerwater *Calonectris diomedea* in the Cabrera National Park, Balearic Islands, Spain. Pp. 70–93 in *Ecologie des oiseaux marins et gestion integree du littoral en Mediterranee* (Walmsley, C.J., Goutner, V., El Hili A. & Sultana J., eds.). *Les amis des oiseaux & Medmaravis*. Arcs Editions, Tunis.

Atkinson, I.A.E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pp. 35–81 in Conservation of island birds (Moors, P.J., ed.). *International Council of Bird Preservation Tech. Pub. 3*.

Baillie, J.E.M., Hilton-Taylor, C, & Stuart, S.N. 2004. *The Iucn Red List of threatened species.* IUCN, The World Conservation Union.

Birdlife International. 2004. *Birds in Europe: population estimates, trends and conservation status.* Cambridge, UK: BirdLife International (BirdLife Conservation Series No. 12).

Blackburn, T.M., Cassey, P., Duncan, R.P., Evans, K.L. & Gaston, K.J. 2004. Avian extinctions and mammalian introductions on oceanic islands. *Science* 305: 1955–1958.

Bourgeois, K. & Vidal, E. 2005. Ecologie et conservation d'un oiseau marin endémique de Méditerranée, *Puffinus yelkouan*. Prédation par le chat haret et sélection de l'habitat de reproduction sur les îles d'Hyères-(T.21-p.55/88)

Brooke, M.De L. 1990. *The Manx Shaerwater*. London: T. & A.D. Poyser.

Caut, S., Angulo, E. & Courchamp F. 2007. Dietary shift of an invasive predator: rats, seabirds and sea tutles. *Journal of Applied Ecology* 45(2): 428–437.

Cheylan, G. 1984. Les mammiferes des iles de Provence et de Mediterranée Occidentale: un esemple de peuplement insulaire non-equilibré? *Revue d'Ecologie* 34: 37–54.

Corbi, F., Francescato, S., Pinos, F., Baccetti, N., Capizzi, D., Sposimo, P., Forcina, G. & Zerunian, S. 2005. Intervento di controllo del Ratto nero nell'isola di Zannone (PNC) a tutela di una colonia di berta maggiore. Pp. 245–252 in *Habitat, flora e fauna del Parco Nazionale del Circeo* (Zerunian, S., ed.). Uff. Gestione Beni ex ASFD di Sabaudia. Parco Nazionale del Circeo.

Cramp, S. & Simmons, K.E.L. 1977. *The Birds of the Western Palearctic*. Volume I, Oxford University Press.

Daycard, L. & Thibault, J.C. 1990. Gestion de la colonie de Puffin cendré (*Calonectris diomedea*) de l'Ille lavezzi (Corse): une experience de dèratisation. *Trav. Sci. Nat. Reg. Reserves Nat. Corse* 28: 55–71.

Granadeiro, J.P., Massa, B. & Lo Valvo, M. 1997. Cory's Shaerwater *Calonectris diomedea*. P. 20 in *The EBCC Atlas of EuropeanBreeding Birds: Their Distribution and Abundance* (Hagemeijer, E.J.M. & Blair, M.J., eds). T & A D Poyser, London.

Granjon, L., Cheylan, G., Duryadi, D., Piraud, N. & Ganem, G.1992. Premières données sur l'ecologie et l'evolution des populations de rats noirs (*Rattus rattus*, L. 1758) des iles Cerbicale (Corse de sud). *Trav. Parc. Nat. Rég. & Rés. nat. Corse*, 39: 97–111.

Hobson, K.A., Drever, M.C. & Kaiser, F.W. 1999. Norway rats as predators of burrow-nesting seabirds: insights from stable isotope analyses. *Journal Wildlife Management* 63: 14–25.

Iapichino, C. & Massa, B. 1989. *The Birds of Sicily*. British Ornithologists' Union. Check-list n. 11, London.

Igual, J.M., Forero, M.G., Gomez, T., Orueta, J.F. & Oro, D. 2006. Rat control and breeding performance in Cory's shearwater (*Calonectris diomedea*): effects of poisoning effort and habitat features. *Animal Conservation* 9: 59–65.

Imber, M.J. 1978. The effect of rats on breeding success of petrels. Pp. 67–72 in: *The ecology and control of rodents in New-Zealand nature reserves* (Dingwall, P.R., Atkinson, I.A.E. & Hay, C., eds.). New Zealand: Department of Land and Survey Information Series.

Lack, D. 1968. *Ecological adaptations for breeding in birds.* London: Methuen.

Martin, J.L., Thibault, J.C. & Bretagnolle, V. 2000. Black rats, island characteristics and colonial nesting birds in the Mediterranean: consequences of an ancient introduction. *Conservation Biology* 14: 1452–1466.

Massa, B. (Red.) 1985. Atlante degli uccelli nidificanti in Sicilia (1979–1983). *Naturalista Sicililiano* 9 (numero speciale). 242 pp.

Massa B., Lo Valvo, M. & La Mantia, T. 1988. Censimento di Berta maggiore (*Calonectris diomedea*) in un'area campione di Linosa (Pelagie): metodo e primi risultati. Pp. 236–240 in: *Metodi e applicabilità alla gestione territoriale* (Pandolfi, M. & Frugis, S. eds.). *Atti I° Semin. Ital., Cens. Faun*., (Urbino, 21–22.IX.82).

Moors, P.J. & Atkinson, I.A.E. 1984. Predation on seabirds by introduced animals and factors affecting in severity. Pp. 667–690 in: *Status and Conservation of the World's Seabirds* (Croxall, J.P., Evans, Pg.H. & Schreiber R.W., eds.). Int. Council Bird Preserv. Tech. Publ. 2.

Moors, P.J., Atkinson, I.A.E. & Sherley, G.H. 1992. Reducing the rat threat to island birds. *Bird Conservation International* 2: 93–114.

Orueta, J.F. & Aranda, R.Y. 1998. Methods to control and eradicate non native terrestrial vertebrate species. *Council of Europe*, Strasbourg, T-PVS, 67e.

Owens, I.P.F. & Bennett, P.M. 2000. Ecological basis of extinction risk in birds: habitat loss versus human persecution and introduced predators. *Proc. Natl. Acad. Sci. USA* 97: 12144–12148.

Palmer, M. & Pons, G.X. 2001. Predicting rat presence on small islands. *Ecography*, 24: 121–126.

Penloup, A., Martin, J.L., Gory, G., Brunstein, D. & Bretagnolle, V. 1997. Distribution and breeding success of pallid swift, *Apus pallidus*, on Mediterranean island: nest predation by the roof rat, *Rattus rattus*, and nest quality. *Oikos* 80: 78–88.

Perfetti, A., Sposimo, P. & Baccetti, N. 2001. Il controllo dei ratti per la conservazione degli uccelli marini nidificanti nelle isole italiane e mediterranee. *Avocetta*, 25: 126.

Stapp, P. 2002. Stable isotopes reveal evidence of predation by ship rats on seabirds on the Shiant Islands, Scotland. *Journal of Applied Ecology* 39: 831–840.

Taylor, R.H., Kaiser, G.W. & Drever, M.C. 2000. Eradication

of Norway rats recovery of seabird habitat on Langara islan, british Columbia. *Restoration Ecology* 8: 151–160.
Thibault, J.C. 1992. Eradication of the brown rat from the Toro Islets (Corsica): remarks about an unwanted colonizer. *Avocetta* 16: 114–117.
Thibault, J.C. 1995. Effect of predation by the black rat *Rattus rattus* on the breeding success of Cory's Shearwater *Calonectris diomedea* in Corsica. *Marine Ornithology* 23: 1–10.
Tucker, G.M. & Heath, M.F. 1994. *Birds in Europe: their conservation status*. Cambridge, U.K: BirdLife International (BirdLife Conservation Series no. 3).
Vidal, P. & Zotier, R. 1998. Rehabilitation ecologique des iles de Marseille (France): une experience de deratisation. Pp. 22–133 in: *Ecologie des oiseaux marins et gestion integree du litoral en Mediterranee* (Walmsley, C.J., Goutner, V., El Hili A. & Sultana J., eds.). *Les amis des oiseaux & Medmaravis*. Arcs Editions, Tunis.
Vigne, J.-D. & Marinval-Vigne, M.C. 1985. Le rat en Corse au 6e siècle après. J.-C. *Mammalia* 49: 138–139.
Whittaker, R.J. 1998. *Island Biogeography*. Oxford University Press.

## Sammanfattning

Introducerade och lättspridda predatorer har varit huvudorsaken till att talrika fågelarter utrotats från öar. De utgör det största hotet mot häckningsframgången för pelagiska arter som liror och stormsvalor eftersom dessa arter har en mycket utdragen häckningsperiod. Dessa havsfåglar har ursprungligen utvecklats på öar där predatorer saknats. Svartråttan är en av de arter som har utrotat fåglar på små öar, och den är en av de vanligaste predatorerna på öar i Medelhavet. Den finns på alla stora och medelstora öar och även på många av de minsta öarna. Kolonisationen har skett med människans hjälp, med undantag för öar nära land dit råttorna simmat. Man har visat att svartråttan kraftigt reducerat häckningsframgången hos fyra arter: gulnäbbad lira, större lira, medelhavslira och stormsvala.

På grund av dessa omständigheter har man under senare år försökt utrota svartråttan från flera öar i Medelhavet. I samband med detta har råttor och fåglar studerats mera i detalj. Bland annat har man funnit att råttorna lever av fåglar i större utsträckning än man tidigare trott eftersom man förmot att de främst var vegetarianer. På ön Linosa som ligger nära Sicilien infördes svartråttan av människan. Antalet råttor har inte kunnat uppskattas, men de finns över hela ön och särskilt i klippig terräng nära kusten. Här häckar också den gulnäbbade liran. Arten är känslig för predation på grund av sin sena könsmognad, bara ett ägg per år, och en lång häckningsperiod, från april till oktober. Gulnäbbade liran minskar över hela sitt utbredningsområde och särskilt i Medelhavet. Den ingår i Annex 1 av EU:s direktiv 79/409 (Fågeldirektivet), den är SPEC2-art i BirdLife Internationals lista över Species of European Concern, och den klassificeras som sårbar av IUCN i den europeiska rödlistan.

Linosa hyser den största kolonin i Italien av gulnäbbad lira (10.000–15.000 par). För att skydda denna koloni påbörjades 2006 en studie för att fastställa de främsta hoten mot kolonin. Arbetet bedrivs av LIPU (Italian Leage for the Protection of Birds) i samarbete med Stazione d'Inanellamento of Palermo. Tänkbara hot var äggtäkt av människor, råttpredation, predation av katter och hundar, biotopförluster på grund av utvidgade mänskliga aktiviteter samt långrevsfiske. Äggtäkt pågick inte och predation av hundar och katter kunde uteslutas studieåret 2006. Denna studie koncentrerades till råttpredationen.

Linosa är en del av Pelagie-arkipelagen mellan Sicilien och Tunisien. Ön har vulkaniskt ursprung, har en kustlängd på 11 km och en areal på 5,4 km2. Linosa är IBA-område (nr 168), SPA-område (ITA040013) och SCI-område (ITA040001). Sedan 2000 är ön också naturreservat. Gulnäbbade liror häckar över hela ön med undantag för en by i söder. Bona placeras under vegetation, under stenar eller i stora otillgängliga grottor. Vår studie genomfördes under hela häckningscykeln 2006, och täckte därför alla faser: ankomsten i mars–april, äggläggningen i maj–juni, kläckningen i juli, uppfödningen av ungarna i juli–oktober samt utflygningen i oktober. Fältarbete utfördes under totalt 64 dagar uppdelat på följande perioder: 20–28 april, 18 maj–11 juni, 21–31 juli, 1–10 september och 11–19 oktober. För vår studie valde vi ett c. 10 ha stort, lättillgängligt område med hög täthet av liror i nordvästra delen av ön. Alla aktiva bon lokaliserades och deras GPS-koordinater registrerades. Råttpredation på ägg fastställdes som förlustorsak om vi fann råttgnag på ägg i eller omedelbart utanför boet. Predation på ungar ansågs föreligga om boet var tomt, det fanns dun i boet, rester av inälvor låg i boet eller ungen saknades där kläckning tidigare konstaterats. Andra predatorer, såsom katter och hundar, kunde uteslutas, hundar därför att de inte alls uppträdde i undersökningsområdet och katter, som dock iakttogs i området, för att kattspår aldrig sågs vid bona. Marken inne i bogångarna täcktes nämligen av ett tunt lager av mjuk sand, och vi noterade aldrig några kattspår medan råttspår och råttspillning påträffades där predation förekommit. De ungar som påträffades döda utanför bona visade också bitskador som var typiska för råttor, inte för katter. Trutar kunde också uteslutas som predatorer. De tar sig inte in i lirornas bon, och den

enda trutkolonin (*michaelis*) låg på andra sidan ön och trutarna lämnade ön i juli, dvs. innan lirorna kläckt.

Vi fann och bevakade 231 bon av gulnäbbad lira (Tabell 1). I juli fann vi 121 ägg eller ungar, 4 övergivna ägg, 1 krossat ägg, 80 prederade ägg och 23 prederade ungar. I två fall fanns en adult fågel i boet utan ägg eller unge. I september hade 91 av de 121 bona från juli fortfarande ägg eller ungar medan 30 hade prederats. I oktober tillkom ingen ytterligare predation. Den totala häckningsframgången blev således 39%, råttpredationen 59% och naturliga förluster 2% (fyra övergivna och ett krossat ägg).

Vi kunde alltså konstatera att råttpredationen var den betydelsefullaste orsaken till reducerad häckningsframgång på Linosa. På andra öar har bl.a. katter spelat stor roll som predatorer, men vi kunde utesluta denna faktor. Vi kunde inte exakt fastställa tidpunkten för predationen, bara att merparten inträffade tidigt under häckningscykeln. Detta stämmer med andra studier. Råttpredationen verkar också infalla i samband med låg produktion hos vegetationen frampå sommaren när torkan sätter in. Råttorna som är omnivorer, men normalt mest äter vegetabilisk föda, blir då i ökad grad predatorer. Mot slutet av häckningen, när lirornas ungar är stora, klarar råttorna av allt att döma inte längre av att döda dem. En skillnad mot studier på andra öar var att vi hade hög predation på äggen, medan andra studier funnit att den högsta predationen inföll närmast efter kläckningen.

På flera andra öar har råttbekämpningen givit positiva resultat. I vissa fall har lirornas häckningsframgång ökat till hundra procent. På Linosa var häckningsframgången bara 39% år 2006. Andra studier har visat att råttornas bestånd såväl som häckningsframgången kan variera kraftigt från år till år. Trots att vår ettåriga studie inte kan fastställa om 2006 var ett typiskt eller ett avvikande år framstår i skenet av studier på andra öar 39% som en mycket låg häckningsframgång. Därför bör bekämpning snabbt ge svar i form av kraftigt ökad häckningsframgång.