

Introduced rats on Guafo Island (Chile) and their potential impact on Sooty Shearwater *Puffinus griseus*

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*Seabirds nesting in island ecosystems are highly vulnerable to introduced predators. Sooty Shearwater (*Puffinus griseus*) form large breeding colonies in southern islands of Chile, South America. However, there are not studies determining the threat degree to this seabird associated to this kind of predators. This article reports the presence of introduced rats in the largest colony of sooty shearwater in the world (Isla Guafo, Chile), discussing the potential impact generated by rats over seabirds.*

Introduction

Seabirds that inhabit and breed on islands are highly vulnerable to predation by introduced mammals such as rats (*Rattus rattus*, *R. norvegicus* and *R. exulans*) (Jones *et al.* 2008), mice (*Mus musculus*) (Wanless *et al.* 2007) and feral cats (*Felis catus*) (Imber 1975). The impact of this predation is particularly acute on islands that lack any native mammalian predators and, as a consequence, the seabirds have limited or non antipredatory strategies (Dulloo *et al.* 2002).



Figure 1. Adult sooty shearwater

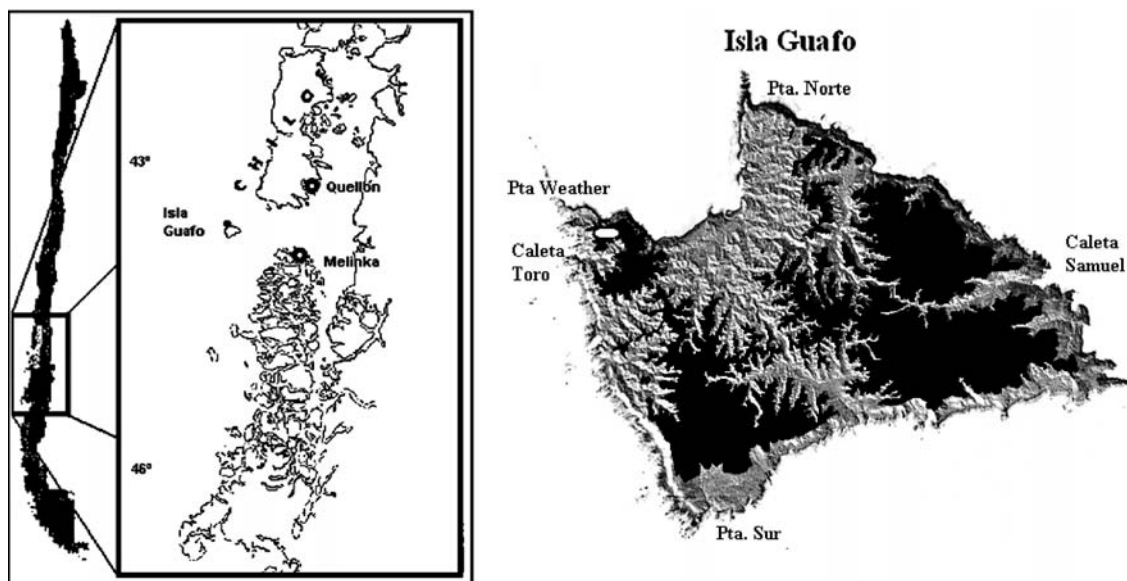


Figure 2. Geographic location map of Guafo Island, Chiloé, Chile. The black areas represent the total surface above the 150 meters above sea level, which correspond to the sooty shearwater nesting areas. The white ellipse highlights the surveyed zone

The sooty shearwater *Puffinus griseus* (Gmelin, 1789; Procellariidae) is a medium-size seabird that nests in burrows located on islands around South-America, Australia and New Zealand (Fig. 1). It breeds in colonies between October and May then migrates to the northern hemisphere during the austral winter (Briggs & Chu 1986, Cooper *et al.* 1991, Spear & Ainley 1999). In New Zealand this species breeds on small and large colonies in a large number of islands (Hamilton *et al.* 1997), reaching 2.75 millions of individuals on Snares Island (Warham & Wilson 1982). There are a total of 20 million pairs estimated in this region (Robertson & Bell 1984). There are also small colonies in southern Australia with approximately 2,000 birds in the largest (e.g. Spear & Ainley 1999).

In relation to the conservation status of *P. griseus*, the IUCN (2009) classifies this species as “near threatened”. There is a large body of published information about the breeding colonies from the western Pacific Ocean, establishing that the population is still decreasing both in their nesting areas as well as in their migratory sites (Hamilton 1997, Veit *et al.* 1996, Scofield & Christie 2002, Uhlmann 2005). A traditional harvest of sooty shearwater chicks by Maoris occurs just before fledging on the islands adjacent to New Zealand. However it is still unknown if this activity is sustainable in the long-term (Gaze 2000, Clucas *et al.* 2008) due to factors such as climatic fluctuations, by-catch (Uhlmann

2005), social and technological change (Lyver & Moller 1999), predation by introduced mammals like dogs (King 2005), stoats (Lyver *et al.* 2000), cats (Brothers 1984) and rats (Gaze 2000, Jones 2000, Harper 2007), all of which may have an impact on population dynamics. For instance, due to the decreasing birth rate that has been observed for many decades on Titi island, New Zealand, the hunting of these seabirds was banned and successful rat eradication campaigns were performed due to their predatory impact on the breeding colonies (*R. norvegicus* (Berkenhout 1769) during the 1960s and 70s) (Gaze 2000).



Figure 3. Chick of sooty shearwater in the burrow nest chamber

Contrary to the New Zealand and Australia scenario, there is scarce information about *P. griseus* population status for the austral islands of South America. However, it is estimated that Chile has the greatest world population of this species (Reyes-Arriagada *et al.* 2007). Reyes-Arriagada *et al.* (2007) indicated that the biggest colony of *P. griseus* in the world is located on Guafo Island, Chile with four million pairs. In 2004 these authors also reported the presence of rodents and feral cats on the island, without information about the rat species. There is no harvest activity of *P. griseus* chicks. This means that the potential impact of these introduced species could be one of the main problems that this breeding colony is facing. The aims of this work were to identify specifically which species of rats live on the *P. griseus* colony on Guafo Island and to search for signs of predation by rats.

Materials and Methods

Guafo Island is located in the Pacific Ocean in front of the Chilean south coast (43° 61' S; 74° 75' W), at approximately 120 km from the shore (Fig. 2). It has an area of 299 km² and raises to 306 m. a.s.l. at its highest point. The *P. griseus* colony is located at 150 m. a.s.l and occupies about 84.411 km². Burrows are located along the steep slopes formed by numerous mountain ranges. These slopes predominate in the area and flat land is almost absent (Reyes-Arriagada *et al.* 2007). Floristic composition corresponds to Laurifolio forest of Chiloé.

During ten days in January 2006 (a period at which all chicks have been hatched and begun their development, see Fig. 3), a grid with 16 snap traps was set, each trap were placed within 10 m of each other, covering a 900 m² area. Traps were covered with a protection device made of wood in order to avoid capturing non-target species (Fig. 4). Rolled oats were used as bait. All traps were checked daily to remove captures and to replace baits. From the captured rats (n=18), four were lost (body parts, tails or legs, were found on traps), therefore only fourteen individuals were weighted and body and tail lengths were measured. This allowed us to identify the rat species. Due to logistic problems, only some of the individual's stomach contents (n=6), were analyzed (Fig. 5). This procedure was qualitatively done describing the type of items found.

Results

Daily rat capture rate was highly variable, showing a mean of 1.8 ± 2.1 (mean \pm SD) (range 0-5, n=18). All captured rats showed a tail length (199.29 ± 17 mm, mean \pm SD, n = 14) bigger than the body length (176.79 ± 19 mm, n=14) and a mean body

mass of 172.86 ± 44.80 g. They all showed a dark colour fur, large naked ears covering the eyes when pulled forward, sharp mouth and a naked tail with epidermal rings. All these features agree with *Rattus rattus* species (Linnaeus, 1758) (Global Invasive Species Database, www.issg.org/database) (For more details see table 1). In the rats stomach content (n=6) both plant and animal remains were recorded including arthropod shells and gray down feathers.



Figure 4. Setting traps in the field.



Figure 5. Dissecting rats for dietary analyses.

Discussion

Although our survey had a restricted capture effort, and temporal and/or spatial biases in the determination of species occurrence should be considered (McArdle *et al.* 1990), a negative interaction between invasive rodents has been reported on several islands (Atkinson 1986, Yom-Tov *et al.* 1999). However, the reason for this interaction may be attributed to factors such as the time of introduction, island size and elevation, island conservation status, among others (Russell & Clout 2004). Because of this, it is necessary to carry out a larger sampling effort to confirm that *R. rattus* is the only invasive rodent present in Guafo Island. But, for instance, in

Seychelles Islands *R. rattus* and *R. norvegicus* did not occur on the same islands (Hill *et al.* 2003).

According to the Global Invasive Species Database (2009) the black rat, *Rattus rattus*, is included in the 100 of the World's Worst Invasive Alien Species list (www.issg.org/database). This species has colonized a large number of islands worldwide, with a significant negative impact on numerous species (eventually leading to bird extinctions). In fact, among the three invasive rat species (*R. rattus*, *R. norvegicus* and *R. exulans* Peale, 1848), *R. rattus* may be considered the most harmful (Jones *et al.* 2008). *R. rattus* was introduced to central Chile during the 1600's, but the introduction date on the islands and archipelagos of southern Chile is unknown (Jaksic 1998).

The stomach content of the *R. rattus* individuals showed that they are probably consuming chicks but it is necessary to perform stable isotopes analyses (^{13}C and ^{15}N) to confirm this and direct observations to discriminate between direct predation and scavenging (Stapp 2002, Caut *et al.* 2008). However, there are many reports that have confirmed rat's predation and its consequences on insular birds (egg, chicks and adults) (e.g. Atkinson 1985, Jouventin *et al.* 2003). *R. rattus* is a general predator that is able to change its diet depending on the resources availability (Caut *et al.* 2008); therefore its presence on Guafo Island implies a potential threat to this seabird and also to other species.

A recent review indicates that rat eradication attempts have been successful, and in the case of black rat eradication have succeeded on 159 islands and failed only on 15 islands (Howald *et al.* 2007), Hermite Island being the largest one with 1022 ha. Guafo Island is one order of magnitude larger than Hermite Island and although an increase in scale could be correlated with an increase in habitat complexity, scale per se has not deterred managers from planning eradication of black rats with an acceptable risk of failure (e.g. Macquarie Island and Tristan da Cunha Island) (Parkes 2008). However basic knowledge of *R. rattus* ecology (e.g. annual intrinsic rate of increase, migration, density fluctuations, breeding season, annual variation in body condition, home range and daily movements) and a full feasibility study (e.g. Parkes 2008) is required to estimate costs, risks and constraints inherent in any attempt to eradicate rats from Guafo Island.

The *P. griseus* colony from Guafo Island is only the third reported in South American waters for this species, and despite of the fact that it is the largest in the world (Reyes-Arriagada *et al.* 2007) it has no formal protection under Chilean laws. Further research is therefore clearly needed for this colony, in

order to improve the basic knowledge and also to implement management and conservation measures, including rat eradication. This is likely to be necessary because although the declines of up to 90% of sooty shearwater populations in the California Current were attributed to factors such as fisheries interaction (Veit *et al.* 1996) and global climate change (Veit *et al.* 1997), the presence of rats and other introduced species on this breeding colony could be a factor contributing to the population decline. Finally, to fully understand the population status of *P. griseus* along the eastern Pacific coast (Chile) more research is required and this must be integrated with the knowledge generated in the western Pacific. This will allow the implementation of management plans and conservation measures at a global scale.

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Table 1. Diagnoses of the principal invasive rat species. For the Guafo Island specimens mean \pm SD is given (n = 14). Modified from King 2005.

Species	<i>R. rattus</i>	<i>R. norvegicus</i>	<i>R. exulans</i>	Checked for Guafo specimens
Adult weight	120-160 up to 225 g	200-300 up to 450 g	60-80 up to 180 g	172.86 \pm 44.80 g
Tail length	Much longer than head-body length	Clearly shorter than head-body length	Slightly shorter or longer than head-body length	199.29 \pm 17.00 mm
Maximum head-body length	225 mm	250 mm	180 mm	176.79 \pm 19.00 mm
Ears	19-26 mm ; cover eyes when pulled forward	14-22 mm ; do not cover eyes when pulled forward	15.50-20.50 mm; cover eyes when pulled forward	Not measured, but cover eyes when pulled forward
Adult hind foot length	28-38 mm	30-41.50 mm	24.5-31 mm	Not noted
Fur on back	Grey-brown or black	Brown	Brown	Dark
Number of nipples	10-12, usually 10	12	8	Not noted