DIET OF THE ATLANTIC PETREL *PTERODROMA INCERTA* DURING THE NON-BREEDING SEASON

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ABSTRACT

PEREZ, M.S., DAUDT, N.W., TAVARES, M., OTT, P.H., SANTOS, R.A. & FONTANA, C.S. 2019. Diet of the Atlantic Petrel *Pterodroma incerta* during the non-breeding season. *Marine Ornithology* 47: 43–47.

The Atlantic Petrel *Pterodroma incerta* breeds during the austral winter and mainly on Gough Island, remaining near the colonies during the breeding season and wintering on the South Atlantic Subtropical Convergence waters. Until now, all information about the diet of this species has been obtained during the breeding season, but these birds may take different prey items on the breeding grounds vs. the wintering grounds. We examined the stomach contents of 61 Atlantic Petrels stranded during the wintering season. A total of 1 183 food items were recorded, mainly cephalopods (93.9 %) and fish (6.1 %). Anthropogenic objects (i.e., debris) were found in 23 birds (37.7 %). Cephalopods are the main prey during both the breeding and the non-breeding seasons. The ingestion of debris by more than one-third of individuals is noteworthy and reveals an additional threat to this endangered species.

Key words: feeding ecology, gadfly petrels, ingested debris, Procellariiformes, South Atlantic Ocean

INTRODUCTION

Albatrosses and petrels have a movement strategy linked to the reproductive cycle, performing as central-place foragers during breeding (Orians & Pearson 1979, Weimerskirch 2007, Rayner *et al.* 2010) and not being tied to land or breeding sites during the non-breeding season (Ramos *et al.* 2015, Ramos *et al.* 2017). These different strategies in opposite seasons can influence the birds' diet, with chick-provision and self-provision food items differing in some cases (Weimerskirch *et al.* 1994, Quillfeldt 2002, Fijn *et al.* 2012, Leal *et al.* 2017). Differences in the diets of individual species can also occur between sexes, breeding-stages, and ages (Hunter & Brooke 1992, Phillips *et al.* 2011, Campioni *et al.* 2016). Moreover, wintering areas may be somewhat different oceanographically. Gadfly petrels *Pterodroma* spp. (Procellariidae) consume a variety of prey, from insects to fish, although they are all squid specialists (Imber 1973, Imber *et al.* 1995, Bester *et al.* 2011, Leal *et al.* 2017).

The Atlantic Petrel *P. incerta* is a medium-sized gadfly petrel (length 43 cm, body mass 420–720 g). It breeds during austral winter (i.e., laying eggs in June–July and chicks fledging in December) on Gough Island and islands of the Tristan da Cunha group in the South Atlantic Ocean (Cuthbert 2004, BirdLife International 2016). The species is regularly recorded in the South Atlantic between 24°S and 50°S, especially in the vicinity of the Subtropical Convergence (Enticott 1991); it is a common visitor off southern Brazil, mainly during the non-breeding season (Neves *et al.* 2006) but also during the breeding season (Dias *et al.* 2017, Ramos *et al.* 2017). Although the population size was estimated at 900 000 breeding pairs (Rexer-Huber *et al.* 2014), the global status of the species is Endangered because of the extremely small breeding range and the evidence of chick predation by introduced house mice *Mus musculus* (Dilley *et al.* 2015, BirdLife International 2016).

The diet of the Atlantic Petrel resembles that of other gadfly petrels, based on data from only one study (Klages & Cooper 1997) and a few other observations (Williams & Imber 1982, Imber 1991). Although these studies indicated a general pattern of squid consumption, they were from single breeding seasons at Gough Island; the species' diet outside the breeding season is unknown.

In general, gadfly petrels are difficult to study due to their nocturnal habits, difficult-to-access breeding sites, and pelagic occurrence. Despite being one of the most diverse taxa of seabirds, they are among the least-known petrels (Croxall *et al.* 2012), especially the Atlantic Petrel (Cuthbert 2004). Information on its annual at-sea distribution is recent (Dias *et al.* 2017, Ramos *et al.* 2017), and the bulk of studies have been conducted on its breeding grounds (Elliott 1957, Swales 1965, Klages & Cooper 1997, Dilley *et al.* 2015). In the present study, we analyzed the gastrointestinal contents of Atlantic Petrels during the non-breeding season by necropsying birds stranded along the southern coast of Brazil.

METHODS

A total of 61 Atlantic Petrel gastrointestinal tracts were analyzed. Most specimens (n = 54) were stranded after the passage of Hurricane Catarina, which hit the southern Brazilian coast in March 2004 (Pezza & Simmonds 2005). The inland displacement of seabirds, including Atlantic Petrels, was detailed by Bugoni *et al.* (2007), although the specimens analyzed here belong to a different set of samples. These specimens were collected by the Laboratório de Biodiversidade e Conservação of Universidade Estadual do Rio Grande do Sul (LABeC/UERGS) and stored in a freezer for later analysis. One additional specimen came from beach-monitoring surveys (January 2013) conducted by the Centro de Estudos Costeiros, Limnológicos e Marinhos of Universidade Federal do Rio Grande do Sul (CECLIMAR/UFRGS). The six other specimens came from petrels that died at the wildlife rehabilitation center Centro de Reabilitação de Animais Silvestres e Marinhos (CERAM/UFRGS) on the northern coast of Rio Grande do Sul state, Brazil, in November–December 2011 (n = 2), January 2013 (n = 3), and January 2014 (n = 1). From those specimens, two could be breeding birds (one was received on 16 November 2011 and other on 25 December 2011), since chicks of this species may fledge until January (Cuthbert 2004). These two specimens were analyzed separately.

In the laboratory, the complete gastrointestinal tract of each bird was extracted and separated into the four cavities (esophagus, proventriculus, ventriculus (gizzard), and intestine), with each cavity investigated separately and washed through a 0.4-mm mesh. All esophagi and intestines were empty. All items found were collected and classified as cephalopod beaks, otoliths and eye lenses from fish/cephalopods, or debris (i.e., any anthropogenic object). In each tract, the number of cephalopods ingested was determined by counting the maximum number of upper or lower beaks, and the number of fish ingested was determined by counting pairs of otoliths or eye lenses. The cephalopod beaks were identified at the lowest possible taxonomic level following the methods of Clarke (1986) and measured under a microscope using an ocular micrometer with 0.1 mm precision. To estimate the mantle length (ML) and body mass (M) of the squids, the regression equations proposed by Clarke (1986), Santos & Haimovici (1998), and Santos (1999) were used. For these estimates, we used the upper rostral length and lower rostral length of the beaks showing little or no wear. The high degree of otolith wear made it impossible to identify the ingested fish species. The numerical frequency (N%) and frequency of occurrence (FO%) were calculated for each food item and piece of debris.

RESULTS

All the gastrointestinal tracts contained food, totaling 1 183 food items (1 090 cephalopod beaks, six otoliths, and 87 fish eye lenses). These numbers represent a minimum of 766 prey, i.e., 719 cephalopods (93.9 %) and 47 fish (6.1 %) of various species (Table 1). From the two possible breeding birds, one had debris in the ventriculus and both presented just cephalopod beaks of the suborder Oegopsida, which was the principal squid group (Table 2). Therefore, they were considered to belong to the same sample as the other Atlantic Petrels (as in Table 1). Most of the cephalopod beaks were found in the ventriculus (94.0 %), showed a high degree of wear (making it difficult to identify the species), and were classified as belonging to the suborder Oegopsida (Table 2). We identified three species among the well-preserved beaks: slender inshore squid *Doryteuthis plei*, São Paulo squid *D. sanpaulensis*, and Verany's long-armed squid *Chiroteuthis veranyi*. Two genera could not be identified to species level: *Chiroteuthis* and *Histioteuthis*. The mean estimated mantle length of the cephalopods (± standard deviation) was 66.2 ± 30.9 mm and the body mass was 51.5 ± 49.4 g (Table 2). Anthropogenic objects were found in 23 birds,

TABLE 1
Frequency of occurrence (FO%) and numerical frequency (N%) of fish and cephalopods consumed by Atlantic Petrels collected along the coast of southern Brazil, 2004–2014

Prey			FO%	N%
Fish	**Total**		**22.9**	**6.1**
	Unidentified		22.9	6.1
Cephalopods	**Total**		**100.0**	**93.9**
	Histioteuthidae	*Histioteuthis*	6.6	0.7
	Chiroteuthidae	*Chiroteuthis veranyi*	3.3	0.3
		Chiroteuthis	1.6	0.1
	Loliginidae	*Doryteuthis plei*	1.6	0.1
		Doryteuthis sanpaulensis	1.6	0.3
	Octopodidae	*Unidentified*	1.6	0.1
	Ommastrephidae	*Unidentified*	1.6	0.1
	Oegopsida	*Unidentified*	100.0	92.2

TABLE 2
Mantle length (ML), body mass (M), and number (*n*) of cephalopods consumed by Atlantic Petrels collected along the coast of southern Brazil, 2004–2014

Prey	ML (mm)			M (g)			
	Mean	*Min.*	*Max.*	*Mean*	*Min.*	*Max.*	*n*
All cephalopods	66.2	28.6	123.9	51.5	1.8	135.5	719
Histioteuthis	59.2	30.8	79.7	84.5	24.4	135.5	5
Chiroteuthis veranyi	114.1	104.4	123.9	38.6	28.9	48.4	2
Chiroteuthis	–	–	–	–	–	–	1
Doryteuthis plei	58.9	–	–	6.5	–	–	1
Doryteuthis sanpaulensis	39.2	28.6	49.8	4.3	1.8	6.7	2
Octopodidae	–	–	–	–	–	–	1
Ommastrephidae	–	–	–	–	–	–	1
Oegopsida	–	–	–	–	–	–	706

i.e., 37.7 % of the tracts. In these birds, the ventriculus contained the most debris (FO% 95.6), although a 26.8-cm plastic tube was found in the proventriculus of one bird.

DISCUSSION

Our results confirm that cephalopods are the most important prey items for the Atlantic Petrel, as is the case for most gadfly petrels (Imber *et al.* 1995, Warham 1996, Leal *et al.* 2017). These findings agree with the data presented by Klages & Cooper (1997), who analyzed the diet of these birds using a natural-regurgitation sampling method during the breeding period on Gough Island. However, cephalopod beaks can remain in the digestive tracts of birds for weeks, while otoliths can be digested in approximately 24–48 h (Furness *et al.* 1984, Jackson & Ryan 1986). Because our sample is mainly from birds displaced inland by Hurricane Catarina and because these birds were emaciated and without fat tissue (Bugoni *et al.* 2007, NWD pers. obs.), it was not surprising to find only a few otoliths and that the beaks were almost all found in the ventriculus.

The suborder Oegopsida, which represented the majority of the prey found, comprises mostly oceanic and deep-water species of cephalopods, including squids of the families Histioteuthidae and Chiroteuthidae (Roper & Young 1975). Some deep-water cephalopods of these groups, such as *Histioteuthis* spp. and *Chiroteuthis* spp., float when dead (Lipinski & Jackson 1989), becoming available to surface-seizers such as Atlantic Petrels. Another possible explanation for the ingestion of deep-water cephalopods by Atlantic Petrels is that nearly all species of these squid groups produce some kind of bioluminescence and make diurnal vertical migrations (summarized by Imber (1973)). Feeding at night and in crepuscular hours is a common behavior of *Pterodroma* petrels and has been documented for many species (Imber 1973, Warham 1996, Rayner *et al.* 2010, Clay *et al.* 2017). *Histioteuthis* spp. and *Chiroteuthis* spp. were previously reported among the food items of Atlantic Petrels in breeding colonies (Williams & Imber 1982, Imber 1991, Klages & Cooper 1997).

Despite their low occurrence and numerical frequencies, coastal cephalopods such as the slender inshore squid (FO% 1.6 and N% 0.1) and São Paulo squid (FO% 1.6 and N% 0.3) were present in the stomach contents. These two cephalopods are reported here for the first time as prey items for the Atlantic Petrel. These squids occur along the southern coast of Brazil (Andriguetto & Haimovici 1991, Haimovici & Perez 1991), indicating that this region could be used, at least by some individuals, as a feeding site in the non-breeding period.

The ingestion of plastic remnants by more than one-third of the individuals is noteworthy. This rate is higher than those reported for other gadfly petrels (Klages & Cooper 1997, Bester *et al.* 2011, Leal *et al.* 2017), but resembles those for similar-sized petrels in southern waters (e.g., Petry & Benemann 2017, Tavares *et al.* 2017). Between the proventriculus and ventriculus in most petrels, there is a constriction (Warham 1996) that can make it difficult to regurgitate objects in the ventriculus, thus leading to accumulation of debris in this chamber (Furness 1985, Pierce *et al.* 2004, Colabuono *et al.* 2009). Despite the similar number of birds analyzed by Klages & Cooper (1997) ($n = 59$) and in the present study ($n = 61$), the FO% of debris was very different: 5.1 % and 37.7 %, respectively. We believe that this difference can be attributed to the different analysis methods employed (i.e., natural-regurgitation vs. necropsy; see Barrett *et al.* (2007) and Provencher *et al.* (2017)) and/or to the accumulation of debris in the ocean in recent years, which, in turn, has led to increased ingestion by seabirds, as noted in other species (Wilcox *et al.* 2015, Di Beneditto & Siciliano 2017, Petry & Benemann 2017). Therefore, the numbers presented here highlight the impact of debris, even for oceanic species.

This first study analyzing the stomach contents of the Atlantic Petrel during the non-breeding season showed that cephalopods are the main prey group of the species year-round. Additionally, we report a high incidence of plastic material consumed by the Atlantic Petrel, calling attention to an additional threat to this endangered species. Moreover, quantifying the prevalence of ingested plastic, at least for Procellariiformes, should be treated with caution, especially if the methodology does not analyze contents of the ventriculus. The predator-prey relationship is an important ecological consideration, and for pelagic seabirds in non-breeding areas, the consumed prey type has often been inferred using indirect techniques (e.g., stable-isotope analysis; Krüger *et al.* 2016, Schultz *et al.* 2018). Nevertheless, the traditional methodology of gut content analysis can still produce important data on food webs and provide the opportunity to record the presence of marine debris.

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