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Nest Predators of Flightless Steamer-Ducks (*Tachyeres pteneres*) and Flying Steamer-Ducks (*Tachyeres patachonicus*)

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Abstract.—A combination of infrared cameras and plasticine eggs were used to identify potential nest predators of Flightless Steamer-Ducks (*Tachyeres pteneres*) and Flying Steamer-Ducks (*T. patachonicus*) and to evaluate the relative efficacy of these methods for identifying predators. Cameras were set up at 31 artificial nests with plasticine eggs and at four Flightless and two Flying steamer-duck nests. Two avian predators, Chimango Caracara (*Milvago chimango*) and Southern Crested Caracara (*Caracara plancus*), and two mammalian predators, Fuegian Culpeo fox (*Pseudalopex culpaeus lycoides*) and American mink (*Neovison vison*), were identified as depredating artificial nests from photos. Active Flightless and Flying steamer-duck nests were found only on islets, and from the photos the Chimango and Southern Crested caracaras were identified as nest predators. Mammalian predators were not photographed on islets (neither on artificial nor natural nests). Though the potential predator community at Lapataia Bay was small, there were considerable similarities in physical evidence and marks left at nests, especially within avian predators. Also, depredated nests were sometimes revisited by other predators and these multi-predator visits sometimes caused changes to the appearance of the depredated nest following departure of the initial predator. The cameras provided an objective method for definitive identification of nest predators. *Received 14 November 2013, accepted 17 December 2013.*

Key words.—American mink, Chimango Caracara, Flightless Steamer-Duck, Flying Steamer-Duck, Fuegian Culpeo fox, nest predators, Southern Crested Caracara, *Tachyeres patachonicus*, *Tachyeres pteneres*.

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Predation on nests is the principal cause of nest failure for most birds (Martin 1993) and plays an important role in overall reproductive success of seashore birds (Neuman *et al.* 2004; Sabine *et al.* 2006). Identifying nest predators that influence nest success is critical for understanding underlying sources of variation in reproductive success and has important management implications to prescribe control or protection efforts.

Many techniques have been used to identify and quantify nest predators and predation, including direct observation (Larivière and Messier 2001), artificial eggs (Götmark *et al.* 1990; Anthony *et al.* 2006), evidence left at nests (e.g., eggshell fragments, tracks, hairs, feces; Hernandez *et al.* 1997) and surveillance cameras (Richardson *et al.* 2009). These methods can produce different results and each is subject to inherent biases (Major and Kendal 1996; Richardson *et al.* 2009). Artificial nests do not duplicate actual nests due to material and methods of construction of nests, egg type, odor, missing adults, etc. (Major and Kendal 1996), and thus may lead to biased responses by nest predators. However, they are useful in identifying potential predators of natural nests (Moore and Robinson 2004), for quantifying relative importance of nest predation across areas or conditions, and for testing effectiveness of identifying predators from nest remains (Anthony *et al.* 2006).

Managers of the Tierra del Fuego National Park (NP) in Argentina were concerned about the numerical declines of solitary ground-nesting birds, mainly Flightless Steamer-Ducks (*Tachyeres pteneres*) and Flying Steamer-Ducks (*T. patachonicus*), along the coast of this protected area and on islets in the Beagle Channel (Administración de Parques Nacionales 2007). The former is categorized as a "Species of Special Value for Conservation" by the Argentinean National Parks Administration (Administración de Parques Nacionales 1994). This paper identifies the ground-nest predators; these data can be used to define strategies for bird conservation and to understand potential effects of the increasing abundance of the introduced American mink (*Neovison vison*) in this region (Valenzuela *et al.* 2014).

Our objectives were to: 1) determine the diversity of potential ground-nest predators in Lapataia Bay (Beagle Channel, Tierra del Fuego NP); 2) identify nest predators of Flightless and Flying steamer-ducks; and 3) evaluate the use of remains/marks left on eggs to identify nest predators.

METHODS

Study Area and Species

We conducted our study along the coastline and on three islets of Lapataia Bay (54° 51' S, 68° 32' W), within the Tierra del Fuego NP, Argentine sector of the Isla Grande de Tierra del Fuego (IGTF; Fig. 1). We focused on two ground-nesting species, the Flightless and the Flying steamer-ducks, that nest along the Beagle Channel.

Potential avian nest predators in the area include raptors: Chimango Caracara (*Milvago chimango*), Southern Crested Caracara (*Polyborus plancus*), White-throated Caracara (*P. albogularis*), Black-crested Buzzard Eagle (*Geranoaelus melanoleucos*), and seabirds: Kelp Gull (*Larus dominicanus*), Dolphin Gull (*L. scoresbii*) and Chilean Skua (*Catharacta chilensis*). Potential mammalian predators included two native and endangered species: southern river otter (*Lontra provocax*) and Fuegian Culpeo fox (*Lycalopex culpaeus lycoides*), and three introduced species: American mink, South American gray fox (*Pseudalopex griseus*) and domestic dog (*Cannis lupus familiaris*).

Data Collection and Analysis

We used two common techniques (cameras and artificial nests) to address managers' needs regarding identification of ground-nest predators and quantification of their relative importance. We located nests of incubating Flightless and Flying steamer-ducks during weekly surveys conducted between 19 November 2012 and 6 January 2013. Additionally, using latex gloves, we constructed artificial nests from local vegetation (dry grass) and duck down collected from abandoned nests, and placed them along the coastline and on three islets (2,657, 1,765, and 1,435 m^2) within Lapataia Bay (Fig. 1). Each artificial nest contained one plasticine egg and two domestic chicken eggs; Bayne and Hobson (1999) demonstrated no difference in predation attraction between plasticine and real eggs. We used passive infra-red motion sensor cameras to monitor all natural and artificial nests (six Bushnell Trophy Cam and four HCO Outdoor Products ScoutGuard SG 550). We set up cameras at 31 artificial nests (27 on the coast, four on islets) and six nests of Flightless ($n = 4$) and Flying ($n = 2$) steamer-ducks, all on islets (we found no Flightless or Flying steamer-duck nests along Lapataia Bay's coastline). We mounted cameras 20-50 cm above the ground and 1.0-1.5 m from nests. We set cameras to shoot 3-2 photos (natural and artificial nests, respectively) when triggered with 10-sec intervals between shot series. Cameras monitored nests 24 hr/day. We revisited natural nests once a week and artificial nests twice a week in the evenings. At each visit, we recorded status of each egg (present and intact/present and damaged/absent) and replaced memory cards/batteries if needed until fate of nest was determined.

We reviewed all photographs and identified predators and time of day when a predator was first observed at the nest. Also, we used photographs at artificial nests to contrast with eggshell evidence and marks left on plasticine eggs associated with that predator.

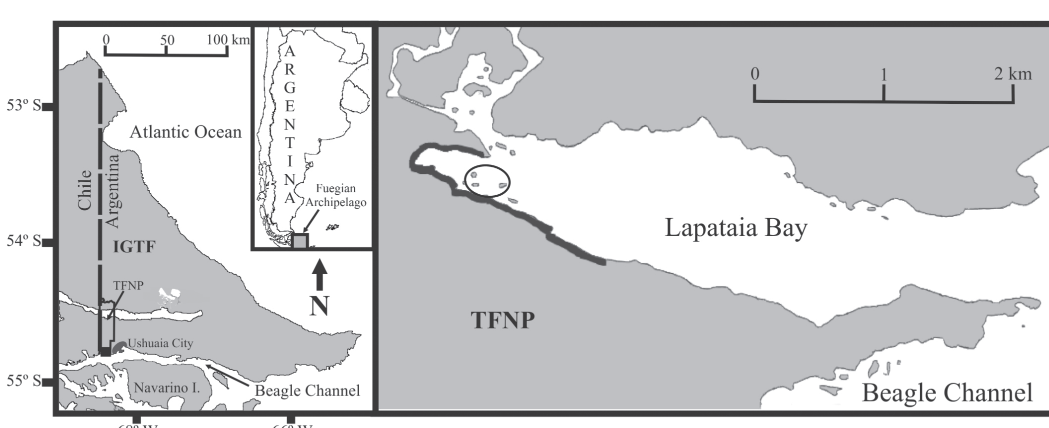

Figure 1. Map showing the study area: IGTF = Isla Grande de Tierra del Fuego, TFNP = Tierra del Fuego National Park. The black line indicates the extension of coastline where artificial nests were deployed. The black circle shows the three islets with Flightless Steamer-Duck (*Tachyeres pteneres*) and Flying Steamer-Duck (*T. patachonicus*) natural and artificial nests.

RESULTS

Nest Predator Species Assemblage

All artificial nests but one were depredated. Of all monitored natural nests, four were depredated, one was abandoned and one had an unknown fate due to a full memory card. Predation events were successfully recorded on cameras except for two occasions on coastal artificial nests. From photographs at artificial nests, we identified four species of potential predators, two native avian and two mammalian: Chimango Caracara, Southern Crested Caracara, Fuegian Culpeo fox and American mink. Mammalian predators were only detected at coastal nests. Avian predators accounted for 23% and mammalian predators for 69% of all predation events recorded on coastal artificial nests, with two events (8%) with unknown predators (Table 1). All predation events on islets were caused by birds, both at artificial and natural nests (Table 1). The Chimango Caracara was the main predator of natural nests (75%), while the Southern Crested Caracara accounted for the remaining 25% of predation events on natural nests (Table 1). Among mammals, predation by the Fuegian Culpeo fox was much higher (65.4% of total predation events on artificial coastal nests) than that caused by the American mink (3.8%; only one event). No other potential native or exotic predator species was recorded. Of all depredated artificial nests, 60% (n = 18) were revisited by the same (50%) or different (50%) species. At depredated natural nests, 75% (n = 3) were revisited by the same (33%) or different species (67%).

Evidence Left at Nest vs. Cameras

All but two of the 22 plasticine eggs recovered (of the 31 deployed) from depredated artificial nests (73%) had visible marks. Avian predators generally left triangular V-shaped marks made by beaks and sometimes talon marks but could not be identified to species level. Mammalian predators sometimes left canine tooth marks (puncture holes, sometimes by pairs a certain distance apart depending on the species) and also incisor tooth marks. We were able to correctly identify predator group from marks in 56% of the plasticine eggs (61.5% mammals and 38.5% avian). However, it was difficult to conclusively identify predators, especially at nests that were revisited by different species. With cameras, we could confirm predator identity in almost all of the monitored nests; this was the only method that allowed reconstruction of sequential predators visits.

All predator species but the American mink left the nest bowl highly disturbed. The Fuegian Culpeo fox generally removed the entire eggs leaving no characteristic shell evidence at the nest (n = 14), and left no feces at the depredated nests. The Chimango and Southern Crested caracaras generally left small eggshell fragments in the nest or nearby and on a few occasions we found the eggshells with a round opening across the middle of the egg.

Table 1. Predators and frequency of predation on Flightless Steamer-Duck (*Tachyeres pteneres*) and Flying Steamer-Duck (*T. patachonicus*) natural and artificial nests. In parenthesis, the percentage of total preyed nests (abandoned nests and nests with unknown fate were excluded).

	Natural Nests	Artificial Nests	
Predators	(On islets only)	Coast	Islets
Chimango Caracara	3 (75)	4 (15.4)	1 (25)
Southern Crested Caracara	1 (25)	2 (7.7)	3 (75)
Fuegian Culpeo fox		17 (65.4)	
American mink		1 (3.8)	
Unknown		2 (7.7)	
Total	4	26	4

Discussion

This study is the first to document with cameras the potential predator assemblage of Flightless and Flying steamer-duck nests. Our evidence indicates that nest predation rates were high, which is consistent with nesting success of many waterfowl species (Butler and Rotella 1998; Opermanis *et al.* 2001).

Mammals (particularly the Fuegian Culpeo fox) were identified as the most common potential predator at coastal ground-nests, but they were never photographed on islets. Instead, Chimango and Southern Crested caracaras accounted for all predation events on islets (artificial and natural nests). The three islets in the study area are close to mainland (0.19, 0.23 and 0.13 km), and mammalian predators could potentially reach them. The semi-aquatic American mink and southern river otter are present on some islands in the Beagle Channel, and the Fuegian Culpeo fox has been previously recorded on one island separated from mainland IGTF by 0.20 km (Liljesthröm *et al.* 2013). However, we only found mammal predation on the mainland, which may explain in part the preference of Flightless and Flying steamer-ducks for offshore nesting sites. Islands could provide a safe place for nesting because they generally offer greater protection against ground predators and human disturbance than continental sites (Lack 1968). This was previously supported at a broader scale for the area (Liljesthröm *et al.* 2013) and for other duck species (Agüero *et al.* 2010). The present findings of mammalian predation only on the coast of the mainland IGTF and the presence of natural nests only on islets also support this idea at a finer scale.

Schüttler *et al.* (2009) conducted a study at Navarino Island, Beagle Channel, which lacks native terrestrial mammalian predators and was recently invaded by American mink (Valenzuela *et al.* 2014). They used eggshell remains and other signs left at the nest to identify predators of Flightless Steamer-Ducks in natural and artificial nests, and found that avian predators (mainly Southern Crested and Chimango caracara) were the most common predator on artificial nests whereas the American mink was the main predator on natural ones. While we cannot compare results on natural nests due to our spatial separation between mammalian predators and nesting sites (no mammals on islets and natural nests only on islets), overall Schüttler *et al.* (2009) and our study show that mammalian predators, when present, are important predators of ground nests and that Chimango and Southern Crested caracaras also are frequent ground nest predators.

Our results support the idea that predator identification solely from appearance of eggs, marks on plasticine eggs, and nest remains is difficult and can lead to misidentification (Larivière 1999; Liebezeit and Zack 2008). Although the potential predator assemblage at Lapataia Bay was small, there were considerable similarities among predators in physical evidence and marks left at nests, especially within avian predators. Different avian species left similar egg remains and marks on plasticine eggs, which did not allow specific identification. Also, multi-predator visits (as seen in our study) can modify the appearance of the depredated nest after the initial predator has left. Instead, cameras at nests provided an objective method to correctly identify predators.

The Fuegian Culpeo fox was the most important potential predator at coastal artificial nests. However, results from camera-identification suggest that the most important predator of Flightless and Flying steamer-ducks in this area are avian, specifically the Chimango Caracara followed by the Southern Crested Caracara. Due to the sample size of natural nests, we are unable to quantify these data for natural nests on other islands of the Beagle Channel (further away from mainland) where the avian community might differ.

Identifying the assemblage of ground-nest predators is important to help define strategies for waterfowl conservation. Contrary to expectations, the American mink was not the main cause of Flightless and Flying steamer-duck nest failures in Tierra del

Fuego NP. However, a continued increase in numbers of this introduced predator could affect waterfowl populations, as high rates of nest predation by American mink have been observed in other regions (Ferreras and Macdonald 1999; Nordström and Korpimäki 2004; Peris *et al.* 2009; Schüttler *et al.* 2009). Therefore, we recommend Tierra del Fuego NP managers monitor and control the American mink to keep their numbers low to avoid their potential negative effects on ground-nesting birds.

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