REPRODUCTIVE ECOLOGY OF THE BLACK-NECKED SWAN *CYGNUS MELANCORYPHUS* IN A MARINE WETLAND OF SOUTHERN CHILE

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ABSTRACT

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The Black-necked Swan *Cygnus melancoryphus* is an endangered species in Chile. After the Río Cruces ecological disaster in Valdivia in 2004 (due to installation of a new pulp mill), the Black-necked Swans that survived were mostly dispersed to marine wetlands of the large island of Chiloé, passing from continental wetlands to the marine environment. The objectives of this study were to provide the first observations of nesting Black-necked Swans in the marine wetland of Chiloé Island, and to identify factors that may affect the survival of their cygnets. Our study was carried out in Caulín Bay (41°49′S; 073°38′W), Chiloé Island, during austral winter and spring of 2011 and 2014. During both years, the Black-necked Swan nested in different sectors of Caulín Bay. The construction of nests began in mid-July, and the first hatchings were recorded in September. In 2011, 23 nests were found in the stone promontories sector and 39 nests were found at Lacaos Island. In 2014, the Black-necked Swan, nesting only in Lacaos Island, occupied 47 nests. We discuss the need to evaluate potential factors that affect the survival of this species' cygnets in the marine wetland of Caulín Bay.

Key words: aquatic birds, Chiloé Island, cygnets, nesting, reproductive success

INTRODUCTION

The Black-necked Swan *Cygnus melancoryphus* is the only representative of its genus in South America and is endemic to Patagonia (Schlatter *et al*. 1991a, MMA 2019). In Chile, it is designated 'Endangered' in the Bío-Bío to Los Lagos Region (SAG 2011). The species' populations are nomadic, moving among different wetlands and functioning as a metapopulation that covers a wide, heterogeneous area (Schlatter 2005).

Installation of a new pulp mill at Río Cruces in 2004 constituted an ecological disaster that affected a protected wetland and its colony of Black-necked Swans. Many swans died, forcing survivors to move (Mulsow & Grandjean 2006, Jaramillo *et al.* 2007). Most of the birds colonized marine wetlands to the north and south, especially at the marine coasts of Chiloé Island (41–43°S; Thomson *et al*. 2009, Valenzuela *et al*. 2015). At Chiloé Island, marine wetlands of international relevance are important for the conservation of migratory and resident aquatic birds (Delgado *et al*. 2010).

Knowledge of the natural history of the Black-necked Swan (hereafter BNS) in Chile is confined to freshwater environments, where it feeds almost exclusively on the invasive aquatic plant *Egeria densa* (Schlatter *et al*. 1991b, Corti & Schlatter 2002). In freshwater environments, it nests alone or in small colonies (Schlatter *et al*. 1991a, 1991b; Silva *et al.* 2012; González & Fariña 2013). In marine wetlands, the tidal cycle affects BNS spatial distribution, and its preferred food source is the marine algae *Ulva taeniata*. In recent years, the species has begun to nest on the coast of Chiloé Island (Cursach *et al*. 2015, Valenzuela *et al*. 2015).

In the current study, we aimed to answer basic questions about the reproduction of BNS, which to date have not been studied in marine wetlands. In accomplishing our goal, we provide the first observations of BNS nesting in the marine wetland of Caulín Bay, Chiloé Island, Chile.

METHODS

Study site

The study was carried out in the marine wetland of Caulín Bay (41°49′S, 073°38′W), located in the Ancud commune, Chiloé Island (Fig. 1). This wetland contains a wide intertidal area and the Huenque River estuary. Lacaos Island is located at the northern margin of this bay, with an area of 71 ha (0.71 km^2); historically, it was used for cattle grazing. BNS nest on the southwest coast of Lacaos Island, building nests in the grass and in some cases protected by shrubs, such as *Ulex europaeus* and *Retama sphaerocarpa*. In addition, there is a stone promontory in the northwest portion of Caulín Bay that becomes a series of small islands during high tide. During extreme low tides, the stone promontory becomes connected by land to the northwestern end of the Caulín coastline. Small patches of vegetation, such as *Selliera radicans* and *U. europaeus*, occur in two sectors of the stone promontory, and BNS use them to nest. A more detailed description of the study area can be found in Encabo *et al*. (2012), Vilugrón *et al*. (2016), and Tobar *et al*. (2017).

Surveys

During August–November 2011 and 2014, BNS family groups were followed by quiet, low-profile walking in order to register numbers of eggs and cygnets per nest. Walking routes depended on tidal and wind conditions. However, the total number of existing nests was always ascertained. Though most of the BNS work occurred in 2011 and 2014, other ornithological work in Caulín Bay was

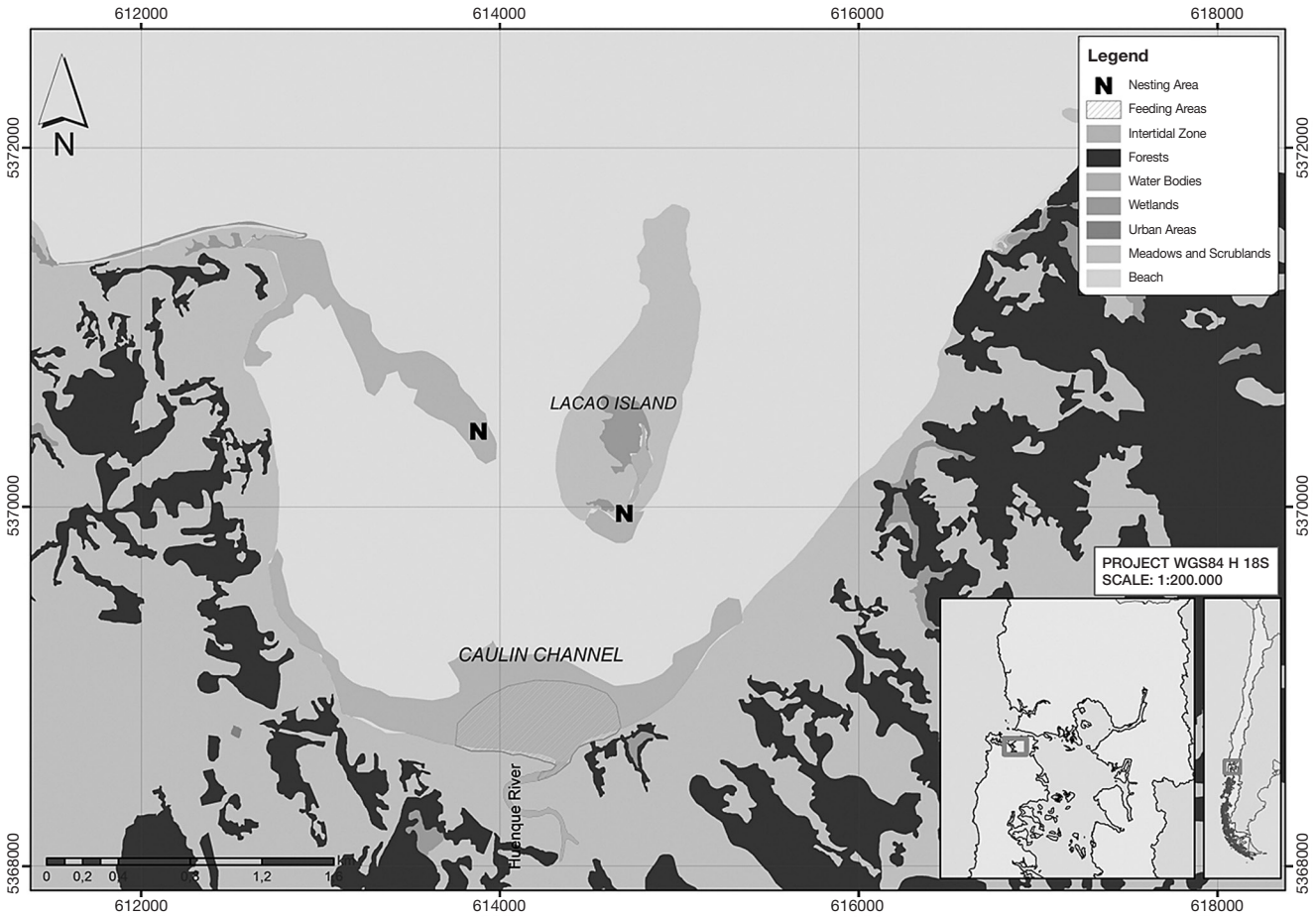

Fig. 1. Locations and characteristics of Black-necked Swan *Cygnus melancoryphus* nesting areas in the marine wetland of Caulín Bay, Chiloé Island, southern Chile. Caulín Bay is located at the northern end of Chiloé Island, within the Los Lagos Region, southern Chile (insets, bottom right).

almost continuous between 2011 and 2014. From these efforts, we added observations about the start dates of the nesting season, as well as the abundance and survival of cygnets. These less-directed observations were performed from the Caulín Bay beach using binoculars (16 × 50) and telescope (40 × 60).

Our final estimate of population size represents the average population counted among surveys. In order to estimate the reproductive success of the BNS, we assumed that half of the BNS adult population (in spring) consisted of females. Reproductive success was then calculated as the number of cygnets divided by the total number of females.

RESULTS

During 2011 and 2014, BNS nested in different sectors of the southeastern coast of Lacaos Island. BNS nested in the stone promontory sector only in 2011 (Table 1).

Each year, the first nesting at Lacaos Island was initiated at the same location, next to a plant of *R. sphaerocarpa* near the seashore. During August 2011, BNS were already brooding, whereas on 12 July 2012, the first active nest of the season was recorded. The following year, on 21 July 2013, the first two active nests were

TABLE 1
Records of the nesting population of the Black-necked Swan *Cygnus melancoryphus* in the stone promontory sector of Caulín Bay, Chiloé Island, southern Chile

Date	Number of nests	Mean of number of eggs per nest	Mode of number of eggs per nest	Range of number of eggs per nest	Total eggs	Number of cygnets
Aug 2011	11	2.4 ± 1.2	3	1–6	24	0
Sept 2011	23	3.2 ± 1.4	4	1–6	67	0
Oct 2011	8	2.3 ± 1.5	2	1–5	14	0
Nov 2011	0				0	0

observed; on 26 July 2014, two pairs were observed initiating nest building. The nests were built between July and September, whereas the incubation of eggs occurred during late August to early November. Hatching occurred between mid-September and mid-December. Care of cygnets took place from September to March.

In general, BNS made their nests directly on the ground using small branches and leaves from shrubs, grass, and stones, as well as seashells from the clam *Venus antiqua* and the gastropod *Crepipatella dilatata* (Fig. 2). In one case, a BNS pair used a polypropylene bag to construct their nest (Fig. 2). The BNS nests were always circular and cake-shaped. During incubation, pairs detached white down to cover the nest crown. We observed that BNS cygnets were born with white down, which became gray with time.

In 2011, the maximum size of the population was 23 nests in the stone promontory sector, with a mode of three eggs per nest (Table 1). In September, eggs began to hatch, but in later visits we observed no BNS cygnets (Table 1). During October, the number of active nests decreased (Table 1), in part due to depredation by two Kelp Gulls *Larus dominicanus* and a Chimango Caracara *Milvago chimango*.

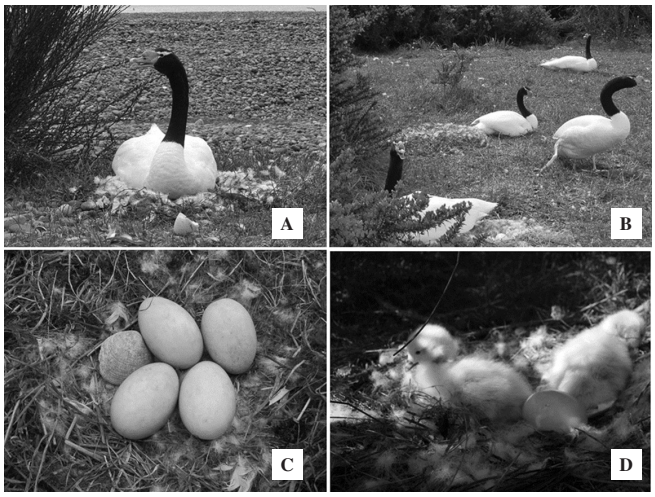

Fig. 2. Black-necked Swans *Cygnus melancoryphus* nesting at Lacaos Island, Caulín Bay, Chiloé Island, southern Chile: (A) active nest; (B) nest grouping; (C) nests with four eggs and a clam shell; and (D) nest with two cygnets and an egg.

In the case of Lacaos Island, a total of 30 nests were registered in 2011, and in 2014 the number of nests increased to 47 (Table 2). In each season, BNS nesting groups increased over time until November, when the number of BNS nesting groups decreased (Table 2). These different groups exhibited different laying periods, indicating time lags in the reproductive synchrony of the nesting groups. In months such as October and November, some nests had a chick and an egg, whereas others had just a chick (sometimes one dead). Empty nests were also observed. It is likely that Southern Crested Caracaras *Caracara plancus*, loitering among the nests, were responsible for these observations, depredating eggs or young chicks from nests. Kelp Gulls seen in the vicinity of the BNS nesting groups may have also been involved in depredation at BNS nests. In addition, it was common to find abundant feces of coypu *Myocastor coypus*, a rodent, in the vicinity of BNS nests. In the Huenque River estuary, we watched a Kelp Gull attack a cygnet in front of its parents, swallowing it quickly. The parents exhibited no resistance, despite having a body size much larger than the predator.

During spring 2011, we estimated an average of 126 ± 16 (standard deviation, SD) BNS in Caulín Bay. Dividing the total number of observed cygnets (n = 7, Table 2) by the number of females (n = 63) indicated a breeding success of 11.1%. In contrast, during spring 2014, we estimated 183 ± 2 BNS in Caulín Bay. Dividing the total number of cygnets (n = 6) by the number of females (n = 92) indicated a breeding success of 17.3% (Table 2).

After the BNS nesting season, we continued to document the number of BNS pairs with surviving cygnets in the marine wetland of Caulín Bay; these pairs were primarily grouped in areas of the Huenque River estuary that were associated with streams that flowed into the bay, where the BNS drink freshwater. From January of each year, the cygnets exhibited gray down and were observed both in the water and on the backs of their parents. Other cygnets were larger, with a back, head, and chest color that was dark gray. They exhibited a whitish abdomen, and the anterior area of their neck was black as they transitioned to adult plumage.

During January 2012, four BNS pairs had a cygnet: two pairs had two cygnets, one pair had three cygnets, and another pair had four cygnets. It was remarkable to observe that between one day and another, these pairs with cygnets disappeared from the wetland but were observed to return on following days, showing the great mobility of the BNS within the Caulín Bay area. However, two months later (March 2012), only one pair with one cygnet (of

TABLE 2
Records of the nesting population of the Black-necked Swan *Cygnus melancoryphus* at Lacaos Island, Chiloé, southern Chile

Date	Number of nests	Mean of number of eggs per nest	Mode of number of eggs per nest	Range of number of eggs per nest	Total eggs	Number of cygnets
Aug 2011	10	2.7 ± 2.1	1	1–6	19	0
Sept 2011	31	3.3 ± 1.6	4	1–6	100	3
Oct 2011	39	3.4 ± 1.6	4	1–8	150	2
Nov 2011	18	3.6 ± 1.4	5	1–6	65	2
Aug 2014	20	2.9 ± 1.6	1	1–6	47	0
Sept 2014	47	3.6 ± 1.4	5	1–5	89	3
Oct 2014	36	3.9 ± 0.9	4	1–6	90	7
Nov 2014	30	3.4 ± 1.4	4	1–6	54	6

advanced development) was observed. In subsequent years, a low abundance of surviving cygnets was also observed. However, our observation efforts were incomplete, which did not permit proper evaluation.

DISCUSSION

In general, our results are similar to those of the BNS described in freshwater wetlands, both in captivity and in the wild (e.g., Haedo-Rossi 1953, Schlatter *et al*. 1991b).

During 2011 in Caulín Bay, a total of 62 BNS nests were located, compared to 47 nests in 2014. In the coastal wetland of El Yali, central Chile, we found that BNS numbers higher markedly during and after El Niño years (ENSO)—periods that were associated with wetter conditions—and these increased BNS numbers were associated with more birds nesting and birds staying longer throughout the summer (Vilina *et al.* 2002). In the case of Caulín Bay, during the seasons studied, no significant ENSO events occurred, although during 2011 the total precipitation was higher than in 2014 (1680.9 mm and 1507.8 mm, respectively; DMC 2012, 2015). Accordingly, in 2011, the number of BNS nests was greater than in 2014. Further studies of BNS in marine wetlands will better evaluate the relationship between the number of nests and density-dependent and climatic factors.

In both years of the study, a small number of BNS cygnets were observed in Caulín Bay, in similar numbers to those observed in other marine wetlands of Chiloé (Valenzuela *et al*. 2015). The factors that affect the survival of BNS cygnets in marine wetlands are not directly known. However, the BNS cygnets were observed swimming with their parents in feeding groups, mainly in the Huenque River estuary and streams that flow into Caulín Bay. The salinity of seawater forces the BNS to move continuously from Lacaos Island to the Huenque River estuary, swimming the strong tidal currents of the Caulín Channel, which can be dangerous for cygnets. The seawater's salinity can also impose physiological constraints on the cygnets when they consume marine plants. Therefore, future research should evaluate how the marine wetland habitat impacts the survival of BNS cygnets.

In the freshwater wetlands of central Chile, the low survival of BNS cygnets can be caused by aggressive BNS adults and natural predators (Schlatter *et al*. 1991b). Interspecific aggression with other aquatic birds also occurs; for instance, BNS are attacked by the Flightless Steamer Duck *Tachyeres pteneres*, as well as territorial seabirds in the marine wetland of Caulín (Araneda *et al*. 2017). In addition, coypu are known to destroy the nests and eggs of aquatic birds in Caulín Bay (Cerda-Peña & Rau 2018). Otherwise, the Southern and Chimango caracaras, along with Kelp Gulls, are the main natural predators of BNS cygnets.

It is necessary to continue the study of nesting waterbirds in the marine wetland of Bahía Caulín. Our efforts identified future lines of research for the BNS, including its nesting and ecological interactions in marine wetland habitats. It is important that future research questions consider the interests of management and conservation of the Bahia Caulín marine wetland, an area that was recently declared a Marine Area for Indigenous Peoples (ECMPO) and that is under the administration of local communities.

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