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NEST SITE SELECTION BY BROWN-HOODED GULL (*LARUS MACULIPENNIS*), TRUDEAU'S TERN (*STERNA TRUDEAUI*) AND WHITE-FACED IBIS (*PLEGADIS CHIBI*) IN A SOUTH CHILEAN TULE MARSH

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Resumen. – Selección de sitios de nidificación de la Gaviota cahuil (*Larus maculipennis*), del Gaviotín piquerito (*Sterna trudeaui*) y del Cuervo de pantano (*Plegadis chibi*) en un pantano en el sur de Chile. – La Gaviota cahuil presentó una selección de sitios de nidificación mas variada que las otras dos especies, construyendo nidos tanto sobre material flotante como en la vegetación suspendidos sobre el agua. Los sitios de nidificación fueron seleccionados con una distancia máxima respecto a la orilla y en pequeños parches de vegetación, los cuales ofrecían mayor cercanía al agua abierta. Se observó sobreposición en la preferencia de selección entre la Gaviota cahuil y el Gaviotín piquerito y entre la Gaviota cahuil y el Cuervo de pantano. Sin embargo, se observó muy poca agresión entre las especies en cuestión, quizá debido a la baja densidad de nidos y la alta disponibilidad de lugares adecuados para la nidificación. Se tomaron datos de parámetros reproductivos de la Gaviota cahuil, para evaluar la función adaptativa de las diferentes localidades y tipos de nidificación. Los nidos en la vegetación resultaron ser mas ventajosos en zonas de aguas agitadas, ya que presentaban menos pérdidas de crías por efecto del impacto del agua, que los nidos flotantes. Sin embargo, se encontró que el éxito de eclosión era similar para ambos tipos de nidos. Los nidos flotantes que presentaron pérdida de huevos por efecto del agua, estaban contruidos mas cerca de aguas abiertas y en zonas con menos material flotante en las inmediaciones del nido que aquellos que no presentaron tales pérdidas. Se observó que la pérdida de huevos por depredación era mayor en los nidos mas cercanos a la orilla.

Abstract. – Nest site selection in Brown-hooded Gull (*Larus maculipennis*), Trudeau's Tern (*Sterna trudeaui*), and White-faced Ibis (*Plegadis chibi*) was studied in a mixed colony in a south Chilean tule marsh. By breeding in nests in the vegetation above the water as well as in floating nests, the gulls used more variable nest sites than the terns and ibises. Nest sites were selected with a maximum distance to the shore and in areas with small tule stands that offer sites close to open water. Site preferences overlapped between gulls and

terns and between gulls and ibises. Nevertheless, little aggression occurred between the species, probably due to low nest densities and good site availability in the study area. Reproductive parameters were collected for the gulls to evaluate the adaptive function of different nest types and nest sites. Nests in the vegetation appear to be advantageous in habitats with strong water movements, because they incurred less brood losses through the impact of water than floating nests. The overall hatching success, however, was similar for all nest types. Floating nests that incurred egg losses through water were built closer to open water and at sites with more water and less floating material in the immediate nest surrounding than floating nests without such egg losses. Nests that incurred egg losses through predation were placed closer to the shore than nests without egg losses through predation. *Accepted 8 February 2001.*

Key words: *Larus maculipennis*, *Plegadis chibi*, *Sterna trudeaui*, nest type, nest site selection, breeding biology, Chile.

INTRODUCTION

Nest site selection, as an aspect of habitat selection, is assumed to have adaptive value, implying that nests are placed at sites that provide optimum conditions for survival and reproduction (Klopfer & Ganzhorn 1985). Correspondingly, breeding in aquatic habitats is interpreted as advantageous in terms of protection from mammalian predators that cannot cross water (Burger 1985). However, aquatic habitats offer only simple vegetation structure for nesting. Nesting birds have therefore adapted to marshes by building floating nests or nests on elevated platforms (Burger 1985).

The Brown-hooded Gull (*Larus maculipennis*) is an abundant breeding species in southern South American marshes and lakes (Murphy 1936, Goodall *et al.* 1957). Its colonies comprise up to several thousand breeding pairs, and the species often breeds in mixed colonies with terns, grebes, ibises, egrets, and other waterbirds (Burger 1974a, Lizurume *et al.* 1995). Despite its abundance, there is little information available on its nesting ecology, especially from Chile. The Trudeau's Tern (*Sterna trudeaui*) has a similar distribution and habitat preference as the Brown-hooded Gull, but it breeds in much smaller numbers. Its colonies usually comprise less than 20 breeding pairs (de la Peña 1977, Schlatter *et al.* 1992). The White-faced

Ibis breeds in North America in the marshes of the Great Basin and in South America, where it is an abundant breeding species in Bolivia, Paraguay, Uruguay, and Argentina (Hancock *et al.* 1992). For the only Chilean population of White-faced Ibises, no substantiated breeding records were available for some decades (Hancock *et al.* 1992). Just in 1991 and subsequent years, single nests were observed in the region of Valdivia (Schlatter *et al.* 1992, S. Mickstein, pers. observ.). The colony we describe here is the first large colony and therefore gives hope that the White-faced Ibis has returned to Chile as a regular breeding species.

In this paper, we compare the nest types and nest sites of the Brown-hooded Gull to those of associated breeding Trudeau's Tern and White-faced Ibis in a south Chilean tule marsh, the Laguna Sto. Domingo. This marsh originated in its present form only 40 years ago during an earthquake that affected southern Chile in May 1960. Many rivers flooded the sagged adjacent land and, subsequently, new marsh habitats were created. Little succession has occurred in these areas until today, forcing the birds to nest in very simple vegetation structure.

We investigated what nest types the birds build under these circumstances and which factors influence nest site selection in each species. By relating nest type and nest site characteristics to reproductive parameters in

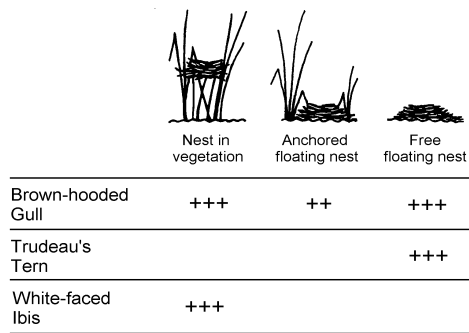


FIG. 1. Nest types of Brown-hooded Gulls, Trudeau's Terns and White-faced Ibises in Laguna Sto. Domingo, Valdivia, Chile. Crosses indicate preferences of specific nest types.

the Brown-hooded Gull, we studied how the observations can be interpreted in terms of maximization of breeding success.

STUDY AREA

The Laguna Sto. Domingo (39°34'S, 73°07'W) is located 20 km southeast of Valdivia in southern Chile. It is a freshwater tule marsh of approximately 1300 ha. Due to its fluvial connection and proximity to the Pacific Ocean, tidal currents occur in the area, and water levels change with up to one meter. The greatest part of the Laguna Sto. Domingo consists of large areas of open water interrupted by monospecific patches of tules (*Scirpus californicus*). Dead tules accumulate in closed ends of open water courses, forming substantial mats of floating material.

The main bird colony was situated in an area with only tules and open water, and counted about 3200 breeding pairs of Brown-hooded Gulls, 80 pairs of White-faced Ibises, and five pairs of Trudeau's Terns. In addition, the area supported a few breeding pairs of Snowy Egrets (*Egretta thula*), Great Grebes (*Podiceps major*), Black-necked Swans (*Cygnus melanocorypha*), Plumbeous Rails (*Pardirallus sanguinolentus*), and Red-gartered Coots (*Fulica*

armillata). The most abundant passerine birds were Many-colored Rush-tyrants (*Tachuris rubrigastra*) and Wren-like Rushbirds (*Phleocryptes melanops*).

Anthropogenic factors apparently did not affect birds in Laguna Sto. Domingo in 1996/97. Gull egg collection by local people has been observed in 1995/96 (S. Mickstein, pers. observ.); however, no egg collection took place during the study year.

METHODS

The study was performed from October to mid March during the 1996/97 breeding season. The bird colony was visited every 2–3 days during the first three months, and about once a week thereafter. Access to the colony was by boat (Zodiac boat with a 15 Hp outboard motor).

In selected typical parts of the colony, all nests of Brown-hooded Gulls, Trudeau's Terns, and White-faced Ibises were individually marked, and nest, nest-site and reproductive parameters were collected from these nests.

Nest descriptions. Nest and nest site descriptions were made, whenever possible, during the first days after laying to prevent bias due to further nest construction during the incubation period.

Each nest was ascribed to one of three different nest types used by the birds in the Laguna Sto. Domingo: nest in vegetation built above the high water level on a platform of bent tules, anchored floating nest, and free floating nest (Fig. 1).

For each nest, the measurements of the cup width, cup depth, upper nest and lower nest diameters as well as the height of the nest from the bottom of the nest to the cup edge were obtained as averages of minimum and maximum values. Nest volume was estimated from the upper nest and lower nest

TABLE 1. Measurements (mean \pm SD) of Brown-hooded Gull, Trudeau's Tern and White-faced Ibis nests in Laguna Sto. Domingo, Chile.

	N	Cup width (cm)	Cup depth (cm)	Upper nest diameter (cm)	Lower nest diameter (cm)	Nest height (cm)	Nest volume (cm ³)
Brown-hooded Gull	66	14.4 \pm 1.6	5.4 \pm 1.0	29.1 \pm 4.3	47.8 \pm 11.3	23.8 \pm 6.5	30.3 \pm 15.2
Trudeau's Tern	6	10.8 \pm 0.5	2.8 \pm 0.4	18.8 \pm 5.8	38.5 \pm 5.8	14.2 \pm 2.9	9.8 \pm 3.7
White-faced Ibis	22	15.3 \pm 1.9 ¹	5.0 \pm 8.2 ²	26.3 \pm 2.8	35.2 \pm 2.6	18.3 \pm 4.1	14.0 \pm 4.0

¹N = 9.²N = 7.

diameters and the height of the nest, assuming the nest was a vertical, truncated cone.

Nest site descriptions. Nest site descriptions included the distance to land [\pm 50 m, estimated from aerial photographs (Fuerza Aerea de Chile 1994/1995)], the distance to open water (referring to areas of open water large enough to serve as resting and refuge sites), the distance to the nearest neighboring nest (both \pm 0.1 m and measured from the nest center), and the vegetation cover in the immediate nest surrounding. The vegetation cover was quantified by estimating the percentage of open water, standing tules and floating material in a 3 x 3 m square around the nest. The vegetation height had no significant influence on the nest placement and is not presented in further details. For a comparison of used and unused sites, the same measurements were taken at sites close to the colony that appeared as appropriate for breeding, but were not used by the birds.

Reproductive parameters. Reproductive parameters were collected for gulls as described by Becker & Finck (1985) and Becker *et al.* (1997). All eggs were individually marked, and their fates were determined during repeated visits to the colony every 2–3 days. The cause of egg loss was determined whenever possible. Eggs that had not hatched after several weeks of incubation were opened to deter-

mine if the embryo had died or the egg was unfertilized.

Due to the small number of Trudeau's Terns' nests and the late discovery of the colony of White-faced Ibises, no reproductive data are provided for these species.

Statistical analysis. Data are reported as mean \pm SD. Nonparametric tests were conducted for data significantly different from the normal distribution. Tests were two-tailed, and a minimum level of $P < 0.05$ was taken as significant.

RESULTS

Nest parameters. Figure 1 shows the nest types used by the three species. Brown-hooded Gulls bred in all three nest types, whereas terns and ibises used only one nest type. Of 106 gull nests 58 (55%) were supported above the water in the vegetation, 15 (14%) were anchored and 33 (31%) were free floating. All of the six tern nests were free floating, and all of the 22 ibis nests were supported above the water.

Nest size parameters for the three species are summarized in Table 1. There were no differences in nest parameters between the three nest types of the gulls. The cup sizes were similar for gull and ibis nests (Table 1), and a few gull pairs bred in old ibis nests.

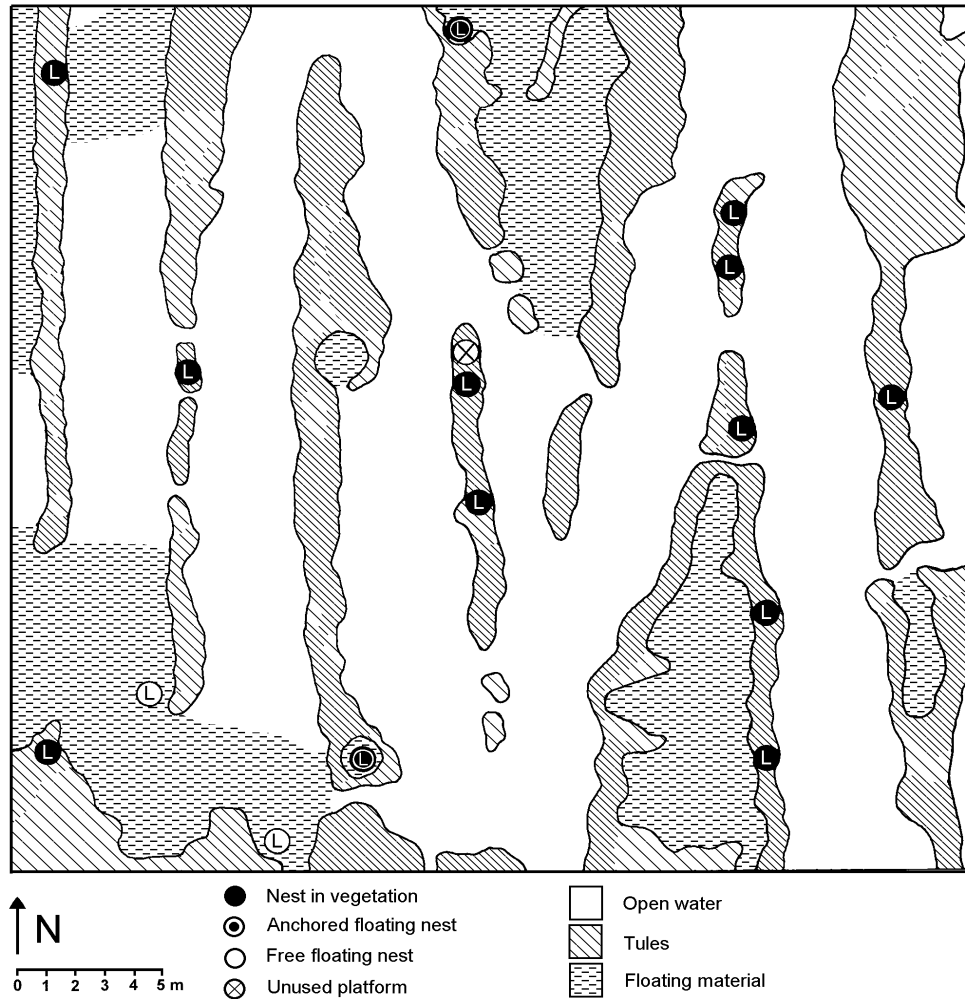


FIG. 2. Representative illustration of the distribution of tules, floating material, open water and nests in a section of Laguna Sto. Domingo occupied by Brown-hooded Gulls (L). Loose, medium and high tulle densities are indicated by different hatching densities.

Nest sites. The breeding birds nested over an area of approximately 100 ha in the central part of the Laguna Sto. Domingo. The nests were placed at distances of 400–750 m from the shore.

Figures 2–4 illustrate the distribution of tules, open water and floating material at representative sites of the colonies. Comparison of these sites to unused sites (maps not pre-

sented) shows that the birds bred in areas with small tulle patches, whereas large and homogenous tulle stands were not used by any of the three species. Small tulle stands offered nest sites close to open water. Mean distances to open water were 1.6 ± 1.3 m for the gulls ($N = 66$), 1.3 ± 0.6 m for the terns ($N = 6$), and 1.7 ± 1.1 m for the ibises ($N = 22$) and did not differ between species

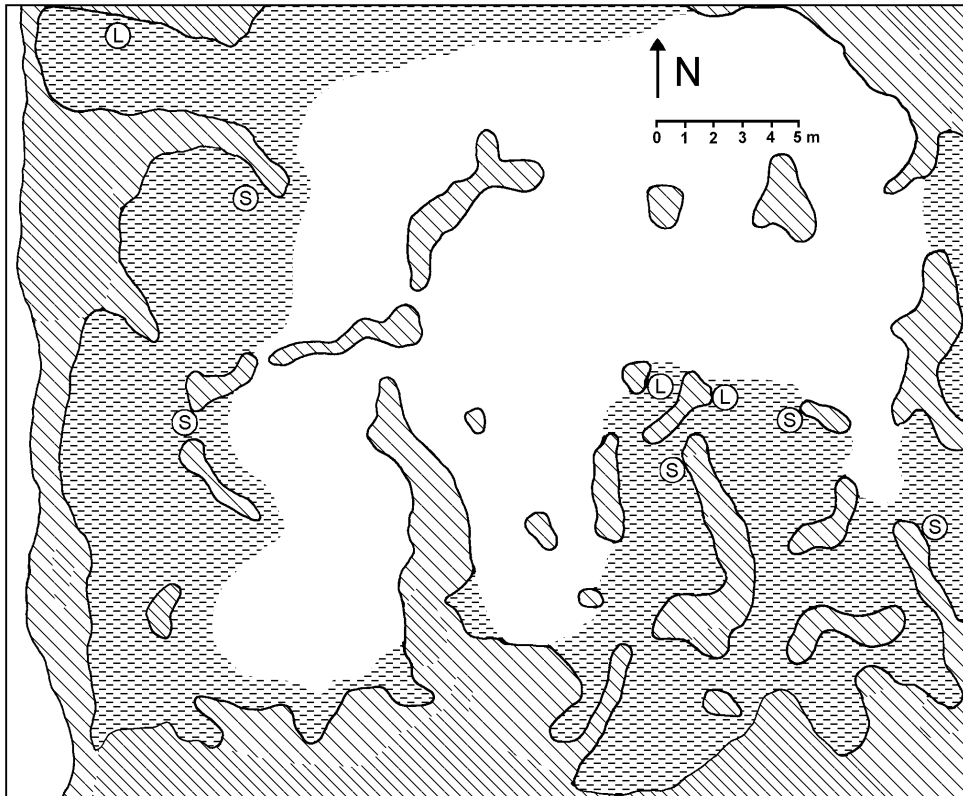


FIG. 3. Representative illustration of the distribution of tules, floating material, open water and nests in a section of Laguna Sto. Domingo occupied by a mixed colony of Brown-hooded Gulls (L) and Trudeau's Terns (S). For legend, see Figure 2.

(Kruskal-Wallis ANOVA, $\chi^2 = 1.12$, $P = 0.57$). Nests in vegetation were built at sites with a minimum tule density of 140 stalks/ m^2 .

The ibis colony was characterized by a platform of bent tules, that extended between the nests (cross hatched in Fig. 4). This platform served as a resting and sleeping place for adult ibises and enabled unfledged chicks to leave their nests without getting into contact with the water.

Figures 2–4 further illustrate the low nest density in the colony. Mean distances to the nearest neighboring nest were 4.7 ± 2.5 m for the gulls ($N = 52$), 3.2 ± 2.2 m for the terns

($N = 6$) and 4.3 ± 2.2 m for the ibises ($N = 22$) and did not differ between species (Kruskal-Wallis ANOVA, $\chi^2 = 2.3$, $P = 0.31$). For 23% of the gull nests no nearest neighbor existed within a radius of 10 m, these nests were, therefore, excluded from the analysis. We observed very few aggressions between neighboring birds and did not find any indication that aggressive interactions between the birds had influenced nest dispersion.

Species-specific site preferences become apparent when the distribution of the vegetation at nest sites is analysed. Figure 5 represents for each nest the approximate coverage of open water, tules, and floating material in

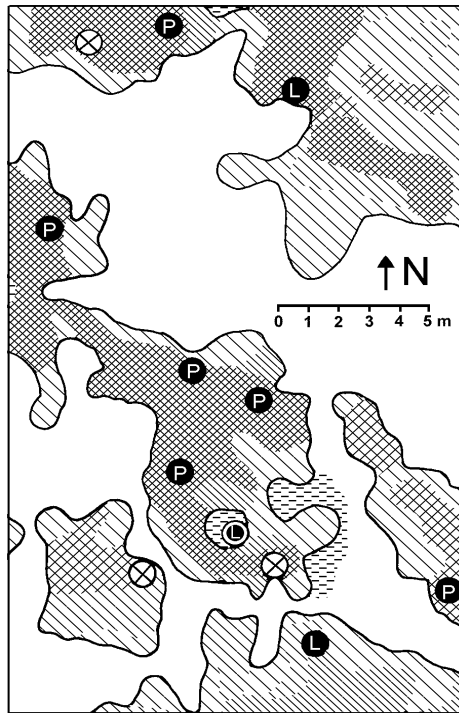


FIG. 4. Representative illustration of the distribution of tules, floating material, open water and nests in a section of Laguna Sto. Domingo occupied by a mixed colony of Brown-hooded Gulls (L) and White-faced Ibises (P). For legend, see Figure 2. The cross-hatched area represents the extension of the platform used by the ibises.

the immediate nest surroundings. Whereas the gulls exhibited a broad habitat use nesting at variable sites (Fig. 5a), the terns preferred open sites with high percentages of floating material (dots in the bottom right corner of the triangle graph; Fig. 5b), and the ibises preferred sites with at least 60% tules around the nest (dots at the top of the triangle; Fig. 5c). A comparison of Figure 5a with Figures 5b and 5c illustrates that the broader habitat use by the gulls was not only attributed to the use of different nest types, but that even within one nest type, the gulls used more variable nest sites than either of the other two species.

Reproductive parameters. The first clutches of Brown-hooded Gulls in the Laguna Sto. Domingo were found on 20 October, and the first eggs hatched on 15 November. The ibises started breeding in mid November. The terns did not lay before 17 December, although they were present in the area from October onwards.

Data on the fate of eggs and causes of egg losses are summarized for gulls in Table 2. The main causes of egg losses were the influence of water, predation and unfertilized eggs. The most abundant predator was the Chimango Caracara (*Milvago chimango*). Crested Caracaras (*Polyborus plancus*) and Kelp Gulls (*Larus dominicanus*) have also been observed. Traces of swimming predators were noted at several predated gull nests. Some of these might have been from the usually vegetarian coypu *Myocastor coypus*.

There were no significant differences in the fate of eggs between the three nest types of gulls (Table 2; Chi-Square Test, $\chi^2 = 7.98$, $P = 0.09$). However, the causes of egg loss differed strongly between nest types (Table 2). Of special interest is the occurrence of egg losses through water in floating nests. Usually, floating nests are considered as an adaptation to changing water levels, because they raise with the water level and therefore are safe from flooding. This suggests that wave action, rather than flooding, has caused egg losses in floating nests. This is further supported by the fact that destruction of floating nests occurred especially after heavy rain. Nests in vegetation did not suffer brood losses through the direct influence of water. However, nests that were built on too little supporting tules were susceptible to collapsing. Predation losses in the Laguna Sto. Domingo were higher in nests located in vegetation than in floating nests (Table 2).

Table 3 presents site characteristics of Brown-hooded Gull nests with egg losses through the influence of water or predation,

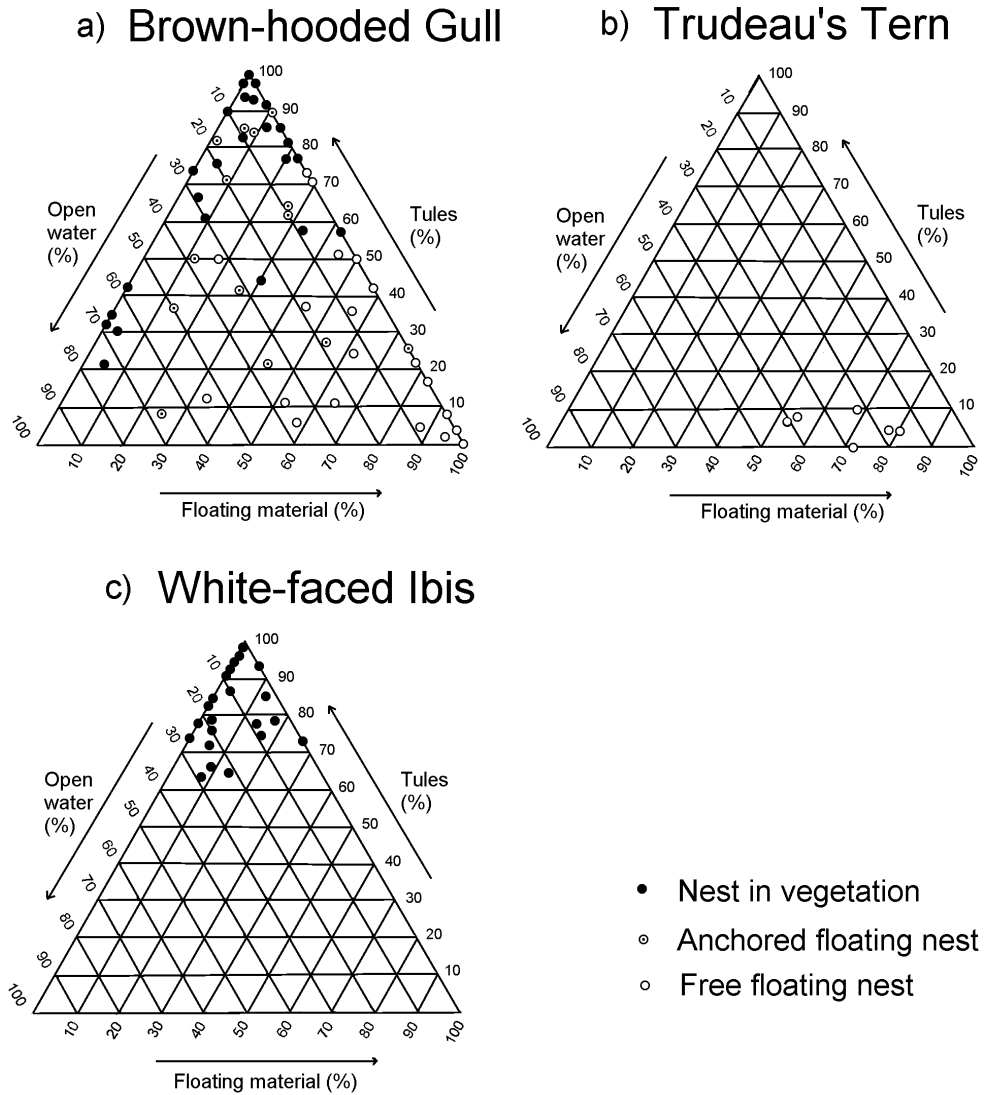


FIG. 5. Approximate coverage of tules, floating material, and open water at the nest sites of a) Brown-hooded Gull, b) Trudeau's Tern, and c) White-faced Ibis.

and nests without egg losses. Nests that suffered egg losses through water were placed significantly closer to open water than nests without losses. Differences were also found depending on the percentage cover of open water and floating material in the immediate nest surroundings (Table 3). The only factor

affecting egg losses through predation was the distance to dry land, since the nests that suffered predation were closer to the shore than those without predation. No differences between nests with and without egg losses were found in the nest size parameters and in further site characteristics (e.g., percentage

TABLE 2. Reproductive parameters of the incubation period for the Brown-hooded Gull.

		Total	Nests in vegetation	Anchored floating nests	Free floating nests
	N (nests)	61	30	14	17
	N (eggs)	122	60	24	38
Fate of eggs	Hatched	30 (24.6%)	17 (28.3%)	7 (29.2%)	6 (15.8%)
	Unknown	29 (23.8%)	10 (16.7%)	4 (16.7%)	15 (39.5%)
	Lost	63 (51.6%)	33 (55.0%)	13 (54.1%)	17 (44.7%)
Cause of egg loss	Unfertilized	12 (9.8%)	8 (13.3%)	2 (8.3%)	2 (5.3%)
	Dead embryo	3 (2.5%)	3 (5.0%)	—	—
	Damaged	3 (2.5%)	—	3 (12.5%)	—
	Predation	15 (12.3%)	13 (21.7%)	—	2 (5.3%)
	Influence of water	20 (16.4%)	—	8 (33.3%)	12 (31.6%)
	Nest collapse	7 (5.7%)	7 (11.7%)	—	—
	Unknown	3 (2.5%)	2 (3.3%)	—	1 (2.6%)

cover of standing tules in the immediate nest surroundings and distance to the nearest neighboring nest).

DISCUSSION

Significance of different nest types. Brown-hooded Gulls are known to build floating nests (MacDonagh 1944, Burger 1974a, Schlatter *et al.* 1992, this study), nests on dry bushes and in emergent vegetation (Barros 1945, 1965; Lizurume *et al.* 1995, this study) and, exceptionally, ground nests (Lizurume *et al.* 1995, D. Guicking & S. Mickstein, pers. observ.). We found nests in the vegetation and free floating nests typical of Brown-hooded Gulls breeding in marshes with tidal influence whereas, in small lakes with stable water levels and less wave action, anchored floating nests are the preferred type (Mickstein & Guicking, unpubl.). Nests in vegetation appear to be advantageous in areas where strong water movements occur and vegetation density is high and strong enough to support stable nest constructions because, under these conditions, floating nests incur high egg losses through the influence of

water (Table 3). However, the fact that gulls had similar hatching successes in all nest types (Table 2) suggests no general adaptive value for nests in vegetation, at least under the conditions observed in Laguna Sto. Domingo.

Trudeau's Terns breed in floating nests (Murphy 1936, de la Peña 1977, Schlatter *et al.* 1992, this study) or in simple depressions on sandy ground (Barros 1945). We found 13 pairs of Trudeau's Terns nesting on windrows (consisting of dead material from submerged plants and tules) washed over the vegetation on semidry islets in Laguna Coluco, a marsh in the northern part of Chiloé island. High nest densities (distances to the nearest neighboring nest 1.5 ± 0.3 m, N = 8, unpubl. data) and the fact that accumulation of floating material similar to that in Laguna Sto. Domingo was present in Laguna Coluco as well but was not used by the terns, suggest that nest sites on windrows were highly preferred by the terns. These observations suggest that free floating nests represent only suboptimal nest sites for Trudeau's Terns in habitats where accumulation of floating material provides the only available platforms for nesting.

TABLE 3. Nest site characteristics (mean \pm SD) of Brown-hooded Gull nests with egg losses through the influence of water or predation, and nests without egg losses.

	Nests with egg losses	Nests without egg losses	Mann-Whitney <i>U</i> -test
Water influence			
N (floating nests)	11	19	
Distance to open water	0.8 \pm 0.8 m	1.8 \pm 1.2 m	$P < 0.05$
% open water around the nest	25.0 \pm 24.3 %	14.7 \pm 18.9 %	n.s.
% floating material around the nest	35.0 \pm 23.8 %	46.9 \pm 32.8 %	n.s.
Predation			
N (all nest types)	9	52	
Distance to land	511 \pm 105 m	609 \pm 91 m	$P < 0.05$

Brown-hooded Gulls breeding in the Laguna Coluco also showed a strong preference for nest sites on windrows.

White-faced Ibises usually breed in nests above the water, either in marsh vegetation or in low bushes and, in some instances, on floating material or on the ground (Mac Donagh 1944, Naroski 1969, Burger & Miller 1977, Schlatter *et al.* 1992). Hancock *et al.* (1992) refer to the nest in vegetation as the typical nest type for the White-faced Ibis. Breeding above the water appears to be of special importance for this species in habitats with changing water levels and strong water movements.

Nest site selection. Besides breeding with furthest distance to the land, small tule stands and proximity to open water were the most important nest site characteristics for Brown-hooded Gulls, Trudeau's Terns, and White-faced Ibises in Laguna Sto. Domingo. Both of these habitat features can be related to predation pressure. Direct evidence was given that gulls' nests with predation losses were placed closer to the shore than nests without losses through predation (Table 3). Most predators approach the colony from dry land and therefore take the prey located closest to the shore. In our study area, proximity to the shore also coincided with proximity to the colony edge,

a nest location considered as disadvantageous with respect to predation (Patterson 1965, Becker 1995).

Breeding at the edge of the vegetation cover means shorter escape for adult birds to open water in case of danger (Burger 1974a). Furthermore, it allows a better view over the surroundings, thus earlier predator sighting and warning, and enhances the visual contact between neighboring pairs. Also, mobbing of approaching swimming predators may be more efficient in open sites than at sites covered with vegetation. The stronger preference for extremely open sites by the terns compared to the gulls (Fig. 3) illustrates the relatively greater importance of these behavioral aspects for the first species.

Ibises do not exhibit a good warning system nor do they show any apparent anti-predator reactions. In case of danger, they leave their nests and fly above the colony until the danger has ceased. Therefore, they might profit from breeding in close neighborhood to gulls or terns as they can react to the warning calls of the associated species. Such a "passive warning system" could be of special importance during the first weeks after hatching when adult birds leave chicks alone during the day, which are still very susceptible to predators. A further advantage of breeding in mixed colonies relates to the swamping effect

(Wittenberger & Hunt 1985). The presence of other breeding birds could therefore be an important factor in nest site selection for the White-faced Ibis.

The impact of water was the second major factor to influence breeding success in the gulls and was shown to be directly related to the nest type and nest site characteristics (Tables 2 and 3). Nests further away from open water and with less water but more floating material in the immediate surroundings were less susceptible to water losses. Evidently, this is because water movements and wave action have higher amplitude in areas of open water but are smoothed in areas covered with floating material. The preference for nest sites with high percentages of floating material by the terns could also be interpreted as an adaptation to reduce the risks of nest destruction through water.

Aggressive interactions with neighboring breeding pairs have been reported to influence nest placement in different species of marsh-nesting gulls (Patterson 1965, Burger 1974a, 1974b, 1976). In Laguna Sto. Domingo, we found no relationship between the distribution or density of the vegetation and the location of the nearest neighboring nest, neither in monospecific parts of the gull colony nor in mixed parts. The average distance to the nearest neighboring nest in Laguna Sto. Domingo (more than 4 m) was extremely large when compared to other colonies of Brown-hooded Gulls, e.g., 1.6 m (Burger 1974a, D. Guicking & S. Mickstein, pers. observ. in Laguna Coluco, Chiloe). These data suggest that appropriate nest sites were not limiting in Laguna Sto. Domingo and aggressions towards neighboring birds were therefore reduced. Bukacinska & Bukacinski (1993) have shown that nest placement of Black-headed Gulls (*Larus ridibundus*) is less influenced by intraspecific aggressions in heterogeneous habitats, particularly when neighboring pairs are separated by open water.

Both conditions apply to nests in Laguna Sto. Domingo.

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