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EFFECTS OF NEST TYPE AND LOCATION ON REPRODUCTIVE SUCCESS OF THE MAGELLANIC PENGUIN *SPHENISCUS MAGELLANICUS*

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SUMMARY

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Nest type and location within the colony influenced egg and chick survival of the Magellanic Penguin *Spheniscus magellanicus* at Punta Tombo, Argentina. In a more central part of the colony, 6.3% of the eggs compared to 23.1% of the eggs in a more peripheral area were lost to predators. Reproductive success was higher in the central area (73.4%) than in the peripheral area (51.3%). Temperature decreased more slowly in burrows than in bushes at night and more slowly in bushes than in burrows during the day. Burrows had the most constant thermal environment which reduced incubation time. Predation was highest in bush nests that provided little cover. Both bush and burrow nests had similar reproductive success.

INTRODUCTION

Nest-site characteristics can influence breeding success of birds (e.g. Austin 1976, Hudson 1982, Martin & Roper 1988, De Bary 1990). Magellanic Penguins *Spheniscus magellanicus* use nests that differ in type (bushes and burrows) and degree of cover (Boswall & McIver 1975, Daciuk 1977, Scolaro *et al.* 1979, 1980, 1984, Boersma *et al.* 1990, Scolaro 1990). Presumably, these nests differ in the degree of protection they provide from predators and thermal stress. Protection of eggs and chicks from predators should affect nest quality (Hudson 1982, Martin & Roper 1988, Seddon & Davis 1989). Shelter from the sun should also be an important determinant of nest-site quality because penguins are easily heat-stressed (Boersma 1976, Frost *et al.* 1976, La Cock 1988, Seddon & Davis 1989). We examined the effects of nest type and nest cover on egg and chick predation rates and fledging success in Magellanic Penguins at Punta Tombo, Argentina. We also tested for differences in the heat-retention capacity of bush and burrow nests, as well as differences in length of incubation period of eggs in the two types of nests.

Magellanic Penguins lay two eggs which are incubated by both parents. Predation is highest during incubation and during the first week after hatching. The main predators on eggs and young of Magellanic Penguin are Kelp Gulls *Larus dominicanus*, along with Subantarctic Skuas *Catharacta antarctica*, armadillos *Chaetophractus villosus*, foxes *Dusicyon griseus* and skunks *Chaetophractus villosus*. Once chicks because mobile and weigh several hundred grams avian predators are almost always unsuccessful at capturing chicks unless the chicks are unattended and very weak.

STUDY AREA AND METHODS

Punta Tombo, Argentina (44 02S, 65 11W) supports a large colony of Magellanic Penguins which nest under bushes and in burrows. The amount of vegetation covering of bush nests varies from nearly none to complete. Burrow nests always have some cover since by definition they have a soil roof. In September 1988 we marked 40 bush nests and 40 burrow nests. Half of the nests of each type were located in an area 250 m inland near the centre of the colony, and half were located in an peripheral area 30 m from the shore. We chose nests that were close to each other and used only nests that had a pair of penguins present. We classified bush nests as having either more, or less than 50% vegetative cover over the nest cup. Burrows were divided into those less than or more than 400 mm in depth. Nests were checked daily from late September when birds lay eggs until early January when chicks begin leaving the home nest (see Boersma *et al.* 1990). At each nest the laying order and nest number were marked on each egg with an indelible felt pen. At each visit we noted nest contents and evidence of predation (shells broken by gulls, footprints of terrestrial predators, small egg fragments left by mammalian predators or eggs missing). Chicks were banded at hatching with fibre bands marked with nest number and hatch order. We determined difference in heat retention of bush and burrow nests by using beer bottles filled with water heated to 40°C. We removed and excluded penguins from their nests to place the bottles about 300 mm inside each of 10 burrow nests, and in the nest bowls of 10 bush nests. The bottles were the same size, shape, colour (brown) and brand. One bottle was placed in the open as a control. The temperature of the water on each bottle was measured to the nearest 1°C approximately every 10 minutes. The temperature of each bottle was measured 10 times during the day and nine times at night, over 100-minute and 60-minute periods, respectively. We used the same procedure to measure temperature change in 10 burrows facing north and 10 facing south.

RESULTS

Predation was patchy and variable but was significantly greater in the peripheral area than in the central area (Chi square = 7.84, df = 1, $P < 0.01$, Table 1). Only signs of avian predation were observed in the central area whereas in the peripheral area there was evidence of both avian and mammalian predation. Reproductive success was higher in the central area than in the peripheral area (Chi square = 4.86, df = 1, $P < 0.05$, Table 1). In the peripheral area pairs which nested in burrows had higher success than those which nested in bushes (Chi square = 5.23, df = 1, $P < 0.05$, Table 1). Predation of eggs was similar in bush (17.5%) and burrow (11.7 total) nests (Chi square = 1.16, df = 1, $P > 0.05$). Chicks survived similarly in bush (81% fledged, n = 58 chicks hatched) and burrow nests (82% fledged, n = 62 chicks hatched) (Chi square = 0.06, df = 1, $P > 0.05$) and breeding success was similar (0.59 chicks fledged per egg laid in bush nests, n = 40; 0.66 chicks fledged per egg laid in burrows, n = 40) (Chi square = 0.20, df = 1, $P > 0.05$). Bush nests with less than 50% coverage were more likely to lose eggs than were bush nests with more than 50% coverage (Chi square = 7.90, df = 1, $P < 0.01$). Burrows less than 400 mm deep and deeper burrows had similar success (Chi square = 0.11, df = 1, $P > 0.05$). Heat loss was slower in burrows than in bushes at night (t = 9.30, df = 16, n = 9, 9, $P < 0.01$) and slower in bushes than burrows during the day (t = 3.47, df = 18, n = 10, 10, $P < 0.01$, Figs 1 &

TABLE 1

EGG PREDATION AND BREEDING SUCCESS OF MAGELLANIC PENGUINS *SPHENISCUS MAGELLANICUS* AT PUNTA TOMBO, ARGENTINA

	Central area			Peripheral area		
	Bushes	Burrows	Both	Bushes	Burrows	Both
Number of nest	20	20	40	20	20	40
Eggs layed	40	39	79	40	38	78
Eggs eaten	2	3	5	12	6	18
Hatching success[1]	90	85	87.3	55	76.3	65.4
Fledging success[2](%)	86.1	81.8	84.1	72.7	82.8	78.4
Breeding success[3](%)	77.5	69.2	73.4	40.0	63.2	51.3

1 No. chicks/No. eggs layed
2 No. chicks fledged/No. chicks hatched
3 No. chicks fledged/No. eggs layed

2). The control bottle placed in the open lost temperature more slowly in the day and more rapidly at night than any of the bottles in bush or burrow nests. North- and south-facing burrows lost heat at similar rates (t = 0.45, n = 10, 10, P >0.05). The dates of egg laying in burrows and bushes were similar (t = 0.88, n = 40, 39, P >0.05). Mean incubation period was significantly shorter for burrows (38.9 d, sd = 1.69) than for bush nests (39.9 d, sd = 2.17) (t = 2.24, n = 28, 33 P <0.05). Chicks born earlier survived longer than those born later (Spearman rank = 0.57, n = 98, P <0.025). Only first chicks were used in this analysis in order to avoid the influence of hatching order and intra-nest competition.

DISCUSSION

We found no difference in fledging or egg predation between bush and burrow nests. This is somewhat surprising given the very different kind and degree of cover provided by the two types of nest. Analysis of a larger sample would be useful to confirm this result.

Bush nests with less coverage experienced significantly more predation than did those with more coverage. De Bary (1990) found that reproductive success in well-covered nests (80-100%) was similar to that with in nests with less cover (60-70%). Eggs and chicks in poor nests (those with less than 50% coverage) may be more easily detected by aerial predators. Moreover, the poorest quality nests may be used by younger penguins and their inexperience may cause lower reproductive success. Younger birds could suffer lower breeding success by poor egg attendance or failed coordination of nest relief (Davis 1982). Confounding factors of age and experience make it difficult to quantify the importance of coverage *per se* in nesting success. Predation rates appear to vary within the colony, being lower in the central inland area than in the peripheral area close to the sea. However, predation was patchy and occurred in both

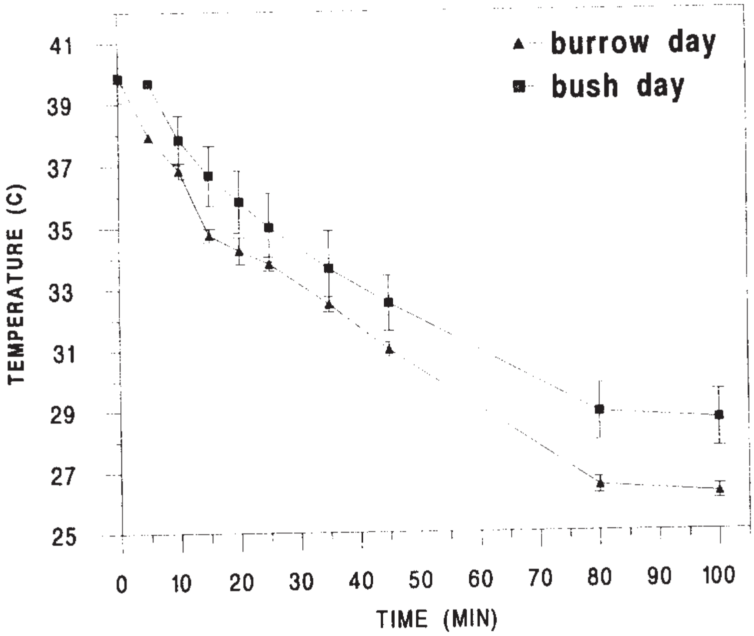

Figure 1

Nocturnal temperature loss of bottles in Magellanic Penguin *Spheniscus magellanicus* burrow and bush nests at Punta Tombo, Argentina (means ± SE)

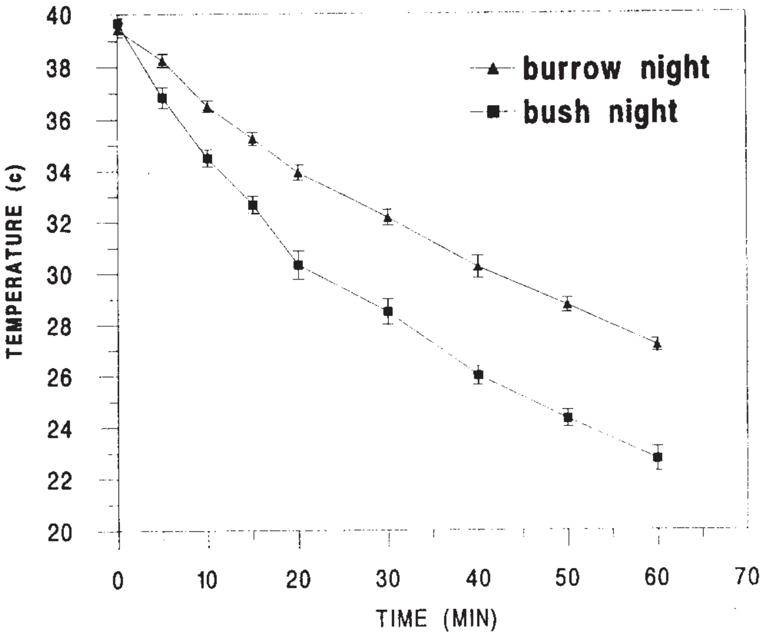

Figure 2

Diurnal temperature loss of bottles in Magellanic Penguin *Spheniscus magellanicus* burrow and bush nests at Punta Tombo, Argentina (means ± SE) the central and peripheral areas which suggests it may be difficult for a penguin to avoid predation by the choice of a nest site. Temperature loss rates in bushes and burrows differed. Consistent with this study, Frost *et al.* (1976) found that burrows of Jackass Penguins *Spheniscus demersus* were warmer at night and cooler during the day than were exposed nests. The thermal properties of nests may influence development time because eggs laid in burrow nests had shorter incubation periods than those in bush nests. This result must be treated with caution, since the mean difference in incubation time is slightly less than the interval between checks (one day). Furthermore, although chicks that hatch earlier have a greater chance of fledging, it is not clear that the one-day difference in incubation period is biologically meaningful. During the egg period, air temperature can range from 0-30°C. The longer incubation period of eggs in bush nests may be caused by the penguins' inability to heat eggs sufficiently at night and the need for the incubating penguins in bush nests to sit more loosely on the eggs during the heat of the day in order to stay cool. The orientation of a burrow nest does not appear to be an important determinant of heat retention. Frost *et al.* (1976) for Jackass Penguins found that burrows facing east heated up more rapidly than west-facing burrows in the morning and the pattern reversed in the afternoon. For Magellanic Penguins local topography and the size of opening of the burrow apparently obscured any effect of the direction of the burrow opening, at least under the ambient conditions during the experiment.

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