SHORT COMMUNICATIONS

Timing of Breeding and Chick Mortality in Central and Peripheral Nests of Magellanic Penguins

MICHAEL GOCHFELD[1]
Columbia University School of Public Health, Division of Environmental Science, 600 West 168th St., New York, New York 10032 USA

The spatial structure, age composition, and social interactions of seabird colonies affect such reproductive attributes as timing and synchrony of egg-laying, egg and clutch size, and overall reproductive success (e.g. Coulson and White 1958, 1960; Coulson and Horobin 1976; Burger and Shisler 1980). Coulson (1968) emphasized that Black-legged Kittiwakes (*Rissa tridactyla*) breeding in the center of a colony had lower annual mortality and higher reproductive success than those breeding on the edge, suggesting that ability to gain and hold central territories was correlated with ability to raise chicks. This called attention to position in a colony as a significant variable influencing breeding success. Reduced success of peripheral vs. central birds has been reported for Adelie Penguins (*Pygoscelis adeliae*) by Tenaza (1971) and Spurr (1975) and for Black-headed Gulls (*Larus ridibundus*) by Patterson (1965). The differences may be due directly to differing habitat quality (such as exposure to predators) or indirectly to the fact that younger, less experienced birds, which would have lower success in any habitat, are unable to establish territories in more central locations.

Centers and edges are not easily defined in many colonies, especially those with irregular geometry. Tenaza (1971) and Spurr (1975) define the edge as a single row of nests bordering a colony, but an edge might actually be many nests deep. For the purpose of this study of the Magellanic Penguin (*Spheniscus magellanicus*), I focused attention on clusters of nests. Edge clusters were those beyond which no other penguins were nesting, while central ones were surrounded by other clusters.

I studied penguins at Punto Tombo, Chubut Province, Argentina during incubation (November 1971) and during the chick phase (December 1970). The colony has been described in detail (e.g. Boswall and Pryterch 1972, Boswall 1973). It is the northernmost major colony of this species, and Boswall and Pryterch (1972) estimated 446,000 pairs in November 1971, while my census, extrapolated from small samples, was 225,000 ± 25,000 pairs in both 1970 and 1971. The colony is far from homogeneous, with some flat, bare, earthen areas being honeycombed with penguin burrows and other areas having mainly rings of nests clustered around the bases of bushes. Most nests were 60 × 80-cm depressions about 25–40 cm deep. Many nests were actually deep tunnels in which the nesting birds could not be seen. Some were shallow scrapes in the open or next to pieces of driftwood, offering little protection. Most nests were clustered around bushes, and I included only such clusters of nests in my study.

I defined peripheral nests as all nests in peripheral clusters, regardless of whether they were on the colony side or the edge side of the clump of bushes. Central nests were in central clusters. The study nests were selected during the first visit in December 1970. I chose six central clusters at random, providing a sample of 277 "central" nests. On the western edge of the colony I chose at random four clusters providing a sample of 73 "edge" nests, and on the northern extreme I examined the 25 nests scattered through a 20 × 50-m area of small shrubs. The same clusters were reexamined in November 1971.

Table 1 compares the nest contents in the three areas in the two seasons. In early November I was present for 4 days during the laying period, about 10 days before the first eggs hatched (Boswall and Pryterch 1972). Five central nests (2%) had three eggs. Comparing the numbers of nest depressions with zero, one, and two eggs, the edge nests had significantly fewer eggs ($\chi^2 = 29.5$, df = 2, $P < 0.001$). Fifty-two of 96 edge nests (54%), but only 17 of 262 center nests (6%), received eggs during my 4-day stay ($\chi^2 = 102$, $P < 0.001$), indicating that egg-laying in at least these edge samples took place significantly later. Overall, there were significantly smaller clutches in these peripheral clusters (Kolmogorov-Smirnoff two-sample test, $P < 0.001$). Thus, the edge samples included later nests with small clutches than did the central samples.

In early December, 93% of the items (eggs or chicks) in the central sample were chicks compared with 89% in peripheral samples. Although not significantly different, this suggests that the edge nests were later in 1970 as well. The central area had 5% of nests with three eggs and/or chicks, which was a

[1] Present address: Occupational Health, New Jersey State Department of Health, Box 1540, Trenton, New Jersey 08625 USA.

TABLE 1. Nest contents of Magellanic Penguins at Punto Tombo, Chubut, Argentina.

	December 1970			November 1971			Percentage of nests	21 October 1972[a]
		Peripheral			Peripheral			
	Center	West	North	Center	West	North		
Nests								
Empty	0[b]	0[b]	0[b]	12	7	6	(6.9%)	29 (7.3%)
1 egg or chick	145	25	10	57	29	11	(27.1%)	72 (18%)
2 eggs or chicks	117	47	15	188	35	8	(64.5%)	294 (73.5%)
3 eggs or chicks	14	1	0	5	0	0	(1.4%)	4 (1%)
4 eggs or chicks	1	0	0	0	0	0		1 (0.2%)
Total nests	277	73	25	262	71	25		400
Contents								
Eggs	30	8	9	448	99	27		676
Live chicks	244	52	7	0	0	0		0
Dead chicks	151	62	24	0	0	0		0
Total items	425	122	40	448	99	27		676
Mean items/nest	1.53	1.67	1.6	1.71	1.39	1.1		1.69

[a] Data from Boswall and McIver 1974.
[b] Empty nests in these areas were not counted in 1970.

percentage significantly greater than that of the peripheral clusters ($\chi^2 = 13.4; P < 0.001$). The peripheral clutches were smaller (fewer two-egg clutches; $\chi^2 = 10.1$, $P < 0.005$). There were 303 live chicks and 237 dead chicks overall, with a significantly greater proportion of live chicks in the central nests ($\chi^2 = 30.6$, $P < 0.001$). The northern edge fared worse than the western edge ($\chi^2 = 14.1$, $P < 0.001$), but the western edge was still significantly worse than the center ($\chi^2 = 9.4$, $P < 0.01$). Because nests were not followed from the time of initiation, it was not possible to ascertain the validity of the observed numbers of eggs and young; nonetheless, these results show significant advantages for the central nests.

There is presently no basis for determining whether central nests fared better because they were in the center or because they were occupied by better penguins (i.e. older, more experienced birds). The two main results of this study are that central birds nested earlier and had larger clutches (including more three-egg clutches) that did peripheral birds, and that there were significantly fewer dead young in central nests. Considering those nests with at least one living chick as successful and those with only dead chicks as failures, the central area fared significantly better than the western edge (69.3% vs. 53% successful nests; $\chi^2 = 6.4$, $P < 0.025$), and the western edge fared better than the northern edge (53% vs. 26% successful nests; $\chi^2 = 4.3$, $P < 0.05$).

Clutch size, exposure to predators, and parental care could all be important factors influencing the differential success. Spurr (1975) found that Adelie Penguin nests in central areas were more likely to be early and to have two eggs than were peripheral nests. The present results are consistent with Spurr's findings. The occurrence of up to 5% of nests with three eggs and/or young (December 1970) is of considerable interest, particularly as three-egg clutches are nearly unknown in Adelie Penguins (Sladen pers. comm.). The rate varies at Punto Tombo, for I found 2% in my 1971 sample, while Boswall and McIver (1974) report 1%. It is impossible to be sure that the nests with three eggs and/or young actually represent the laying effort of a single female. It is likely that some or most were artifacts. Humans could have deliberately moved eggs from one nest to another. In other penguin species, birds disturbed by humans or predators might dislodge eggs, which could result in supernormal clutches, but, considering the deep nests of the Magellanic Penguin, such accidents are unlikely. Once chicks are old enough to move, they may wander when unguarded and could enter neighboring untended nests. Nests would not be untended, however, unless the birds were exposed to significant disturbance. At Punto Tombo, tourist visits are sufficiently frequent to account for such disturbance. Pettingill (1960) found that, on the Falkland Islands, Magellanic Penguins are easily frightened by people, but this is not true at Punto Tombo (pers. obs., Boswall and McIver 1974). At present, it is impossible to say how many three-egg clutches occur naturally, but future students should be alert to this interesting phenomenon.

The differential success rate may also be due in part to human disturbance, which is much heavier on the periphery (particularly the western edge) than in the center. The role of predation must also be considered. I believe that, whereas peripheral nests in a colony are more vulnerable to terrestrial predators, central nests may be more likely to suffer from aerial predators. This hazard of central nesting has been reported for Laughing Gulls (*Larus atricilla*) by Montevecchi (1977) and for Common Terns (*Sterna hirundo*) (Burger and Lesser 1978). In the latter study, Herring Gull (*L. argentatus*) predation was greater in the center of colonies, and I (unpublished data) have found Marsh Hawks (*Circus cyaneus*) preying on central-nesting terns. At Punto Tombo this hazard would be exacerbated by the fact that the main potential predators, Kelp Gulls (*L. dominicanus*) and Chilean Skuas (*Catharacta chilensis*), actually nest within the penguin colony. These predators are likely to remove completely the egg or chick, so the loss would not be apparent in this kind of study. Such predation could contribute to the lower mean number of items per nest in the edges of Punto Tombo. I did not directly observe predation on penguins at Punto Tombo, but Conway (1971) did.

Predation at penguin nests is not likely while the adults are in attendance. Careless incubation, such as might be practiced by inexperienced adults or by birds with only one egg (see Spurr 1975), might expose nest contents to predators. The most likely cause of exposure, however, is humans frightening the attending adults from the nest. I found that such disturbance played a key role in facilitating predation by Dolphin Gulls (*L. scoresbii*) on cormorant eggs at Punto Tombo (Kury and Gochfeld 1975), and Sladen (pers. comm.) emphasizes this for penguins as well.

It seems likely that human disturbance at the edge of the penguin colony might expose these birds to avian or other predators, and this effect would be enhanced if, as Coulson (1968) noted, the peripheral birds were also younger and less experienced. If the live young I found survived to fledging, central nests would have raised an average of 0.88 young vs. 0.60 young for peripheral nests. The interyear variability in these estimates should be determined. The Punto Tombo colony lies in an important tourist area that is being heavily promoted. Unsupervised human disturbance of this colony is likely to increase. Controlled access coupled with education is desirable. The nesting seabirds appear tolerant of moderate disturbance and succeed in raising young despite frequent human presence. The differential success observed in the present study should be considered both in management schemes and in future studies.

Field work in Argentina was supported by the Frank M. Chapman Memorial Fund. I benefited greatly from Dr. Juan Daciuk's field experience in Patagonia and from discussions with J. Boswall, R. Pryterch, and M. Rumboll. Drs. J. Burger, W. J. L. Sladen, and G. E. Watson provided valuable criticisms of the manuscript.

Literature Cited

Boswall, J. 1973. Supplementary notes on the birds of Point Tombo, Argentina. Bull. Brit. Ornithol. Club 93: 33–36.

———, & D. McIver. 1974. The Magellanic Penguin, *Spheniscus magellanicus*. Pp. 271–305 *in* The biology of penguins, (B. Stonehouse, Ed.). Baltimore, Maryland, University Park Press.

———, & R. J. Pryterch. 1972. Some notes on the birds of Point Tombo, Argentina. Bull. Brit. Ornithol. Club 92: 118–129.

Burger, J., & F. Lesser. 1978. Colony and nest site selection in Common Terns. Ibis 120: 433–449.

———, & J. K. Shisler. 1980. Colony formation and dynamics in Herring Gulls *Larus argentatus* in New Jersey. Ibis in press.

Conway, W. G. 1971. Predation on penguins at Punta Tombo. Anim. Kingdom 74: 2–8.

Coulson, J. C. 1968. Differences in the quality of birds nesting in the centre and on the edges of a colony. Nature 217: 478–479.

———, & J. Horobin. 1976. The influence of age on the breeding biology and survival of the Arctic Tern, *Sterna paradisaea*. J. Zool. 178: 247–260.

———, & E. White. 1958. The effect of age on the breeding biology of the Kittiwake *Rissa tridactyla*. Ibis 100: 40–51.

———, & ———. 1960. The effect of age and density of breeding birds on the time of breeding of the Kittiwake *Rissa tridactyla*. Ibis 102: 71–86.

Kury, C. R., & M. Gochfeld. 1975. Human interference and gull predation in cormorant colonies. Biol. Conserv. 8: 23–34.

Montevecchi, W. 1977. Predation in a salt marsh Laughing Gull colony. Auk 94: 583–585.

Patterson, I. H. 1965. Timing and spacing of broods in the Black-headed Gull *Larus ridibundus*. Ibis 107: 433–459.

Pettingill, E. R. 1960. Penguin summer. New York, Clarkson N. Potter.

Spurr, E. B. 1975. Breeding of the Adelie Penguin *Pygoscelis adeliae* at Cape Bird. Ibis 117: 324–338.

Tenaza, R. 1971. Behaviour and nesting success relative to nest location in Adelie Penguins (*Pygoscelis adeliae*). Condor 83: 81–92.

Received 29 December 1978, accepted 17 September 1979.