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MICROCLIMATIC FEATURES OF GRAY GULL, *LARUS MODESTUS*, NESTS IN THE ATACAMA DESERT

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INTRODUCTION

Gray Gulls, *Larus modestus*, nest in the barren and lifeless pampas of the Atacama Desert of northern Chile, 35 - 100 km from the coast (Goodall *et al.*, 1945; Howell *et al.*, 1974; Guerra and Cikutovic, 1983; Guerra *et al.*, 1988). Intense solar radiation and daily extremes and variation in wind velocity (0 - 833 ms^{-1}), relative humidity (6 - 99 percent), air temperature (2.5 - 38°C) and surface temperature (2 - 61° C) (Howell *et al.*, 1974; Guerra and Cikutovic, 1983; Guerra *et al.*; 1988a, b; our unpublished data) impose severe challenges to the thermoregulatory ability of incubating and brooding adults (Fitzpatrick *et al.*, 1988) and unattended chicks. During the hottest and driest hours of the day 12:00-16:00h.; Guerra and Cikutovic, 1983; Guerra *et al.*, 1988a, b), incubating adult Gray Gulls are forced to stand to convectively thermoregulate in the wind (Howell *et al.*, 1974; Guerra *et al.*, 1988b). Erection of their gray plumage enables adults to reduce the heat load transmitted to their skin (see Walsberg *et al.*, 1978). Since chicks are smaller, lighter in color (for crypsis) than the adults and lack ability to erect plumage, they are more likely to incur water deficits through evaporative cooling (*e.g.*, panting) and defecation than adults. Since their only source of water is in food brought nightly by adults from the coast, chicks must somehow minimize its loss.

Elsewhere, we hypothesized that use of two types of nests by Gray Gulls (Fig. 1A) relates to differences in microclimatic conditions between them (Guerra *et al.*, 1988a). Since organic material is not available in the Atacama pampas, Gray Gull nests consist of simple scraps containing only sand and small pebbles (Howell *et al.*, 1974; Guerra *et al.*, 1988a). Nests located in the open and exposed to desert winds are used by incubating and brooding adults for 35-37 days (Howell *et al.*, 1974; personal observation). The others, located immediately adjacent to small rocks and sides of shallow dry channels cut in the alluvial substrate are described in Guerra *et al.* (1988a) as refuges used by unattended chicks for thermoregulation during the day when coastal winds blow from the NW and at night when cold Andean winds are from the E-NE. Guerra *et al.* (1988a) hypothesized that location of scrapes, surrounded by guano accumulations, immediately juxtaposed to the SW side of small rocks (Fig. 1B) provides more favorable micrometeorological conditions throughout the day for chicks. In a random sample of 68 small rocks used by chicks, 92.6 percent of the refuges were on the SW side. Since all the active and inactive nesting sites of Gray Gulls which we have observed during the past seven years are located only where small rocks are strewn over the surface, we consider them to be essential for successful nesting. Herein, we present detailed information supporting that contention.

METHODS

Data presented herein are from a nesting site located 100 km east from the coast at Antofagasta near Cerro Negro. Nesting sites at Cerro Negro are described in Guerra and Cikutovic (1983) and Guerra *et al.* (1988a). Daily measurements of wind velocity and direction, air and surface temperatures (T_A and T_G), and relative humidity (RH) were taken with one or more of the following instruments: Datametrics 100 UT air flow meter; Digi-Sense Type K Thermocouple digital thermometer with psychrometer probe; Anemo anemometer; and YSI 12-channel telethermometer with thermistor leads/probes, every 1 - 2 h on 14 - 15 January 1982, 30 - 31 January 1983, 4 - 5 February 1986 and 19 - 20 February 1987 at a typical, but vacant, rock refuge located at Cerro Negro. Shaded probes, attached to the telethermometer, were placed 2-3 mm beneath the surface, at each of eight cardinal points around the rock (N, NE, E, SE, S, SW, W, NW), on the rock surface, within a dry channel refuge (see Fig. 1a, b measure T_G. At each location, except the rock surface, T_A, RH, and wind velocity and direction also were measured.

RESULTS

Daily patterns of RH, T_A and T_G during the nesting season are given in Fig. 2. RH was highest in the early morning when T_A and T_G were minimal. On the few mornings when the dew point is reached, fog forms from ground level to 10 m, wetting rock surfaces. The fog, locally called "camanchaca", dissipates with sunrise and RH falls to 6 - 9 percent by midday. Highest and lowest temperatures were between 12:00 and 16:00, and 03:00 and 07:00 h, respectively. The highest T_A was 35°C ($\bar{x} \pm$ SD = 33.8 $\pm$ 1.9; 14:00 h; N = 4) and T_G was 61°C (55.2 $\pm$ 5.1; 14:00 h; N = 4). The lowest T_A was 9°C (9.7 $\pm$ 1.0; 07:00 h; N = 4) and T_G was 10°C (12.8 $\pm$ 2.0; 06:00; N = 4). Elswhere, we reported a T_G of 2.0°C (Guerra *et al.*, 1988a).

Desert winds at Cerro Negro typically are from the NW, which rotate *ca.*

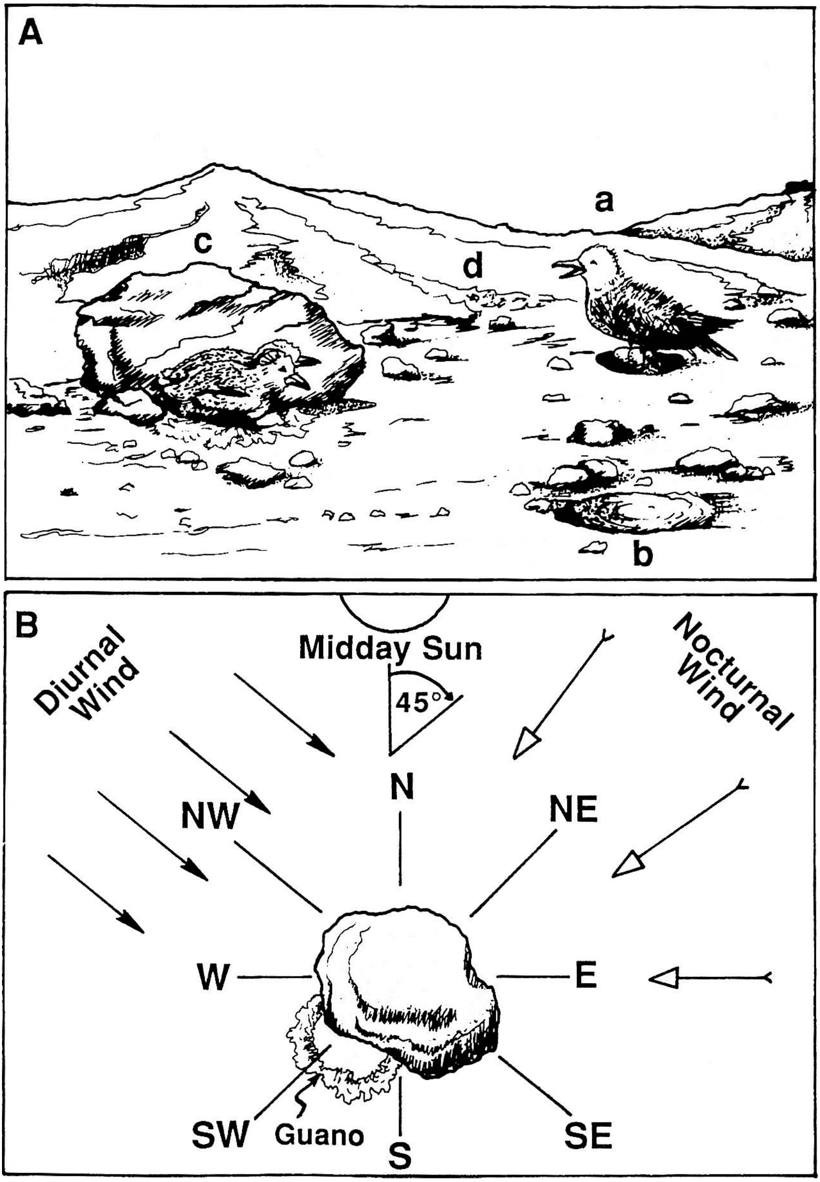

Fig. 1. A. Schematic view of a typical Cerro Negro desert nesting site, showing an incubating adult thermoregulating and shading eggs (a), an empty incubation scrape (b), a chick refuge next to a rock (c) and a dry channel used by chicks for refuges (d).

B. Relation of a chick refuge, defined by a ring of guano, to daily winds and sun at midday.

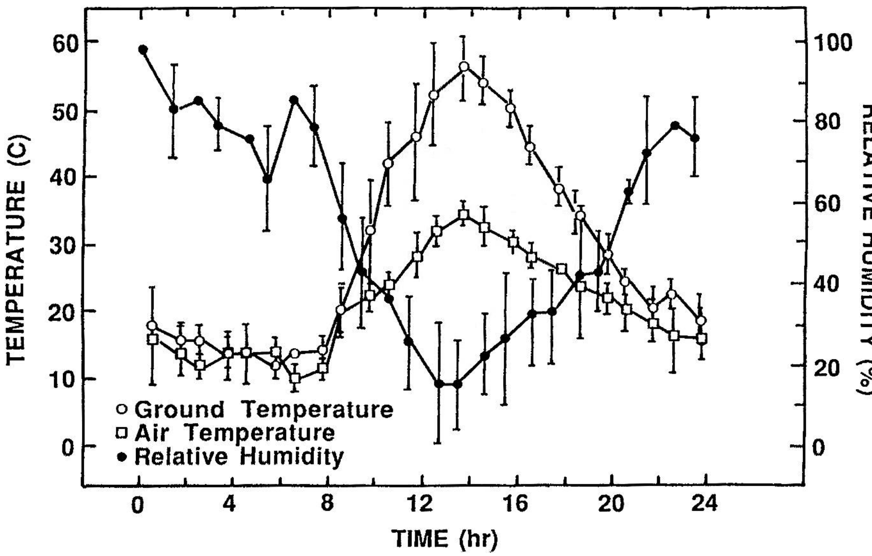

Fig. 2. Daily fluctuation of relative humidity, ground and air temperature ($\bar{x} \pm$ sd) at the Cerro Negro nesting site of Gray Gulls, *Larus modestus*, during January 1982, 1983, February 1986, 1987.

90° as they pass over and through the coastal mountains, averaged 12.8 m s^{-1} between 10:00 and 20:00 h. The air was still from 20:00 to 03:00 h. Between 03:00 and 06:00 the cold-dry Andean wind blew from E-NE at 2 - 3 m s^{-1}, chilling the desert and subjecting Gray Gulls to lowest daily temperatures. Variations in T_G and wind velocity around the rock refuge are displayed in Fig. 3 and 4, respectively. Though RH varied throughout the day, it did not vary around the rock or among microhabitats as did T_A and T_G. The shaded area in Fig. 3 shows that the lowest T_G during the hottest period (11:00-14:00 h.) occurred at the SW side, coincident with the chick refuge. In Fig. 4, the shaded area showed that the S-SW-W area, which includes the refuge, received the highest wind velocity around the rock during the same period, which would facilitate convective cooling of chicks. In contrast, when the cold E-NE winds from the Andes blew, the SW-located refuge had the lowest velocities which

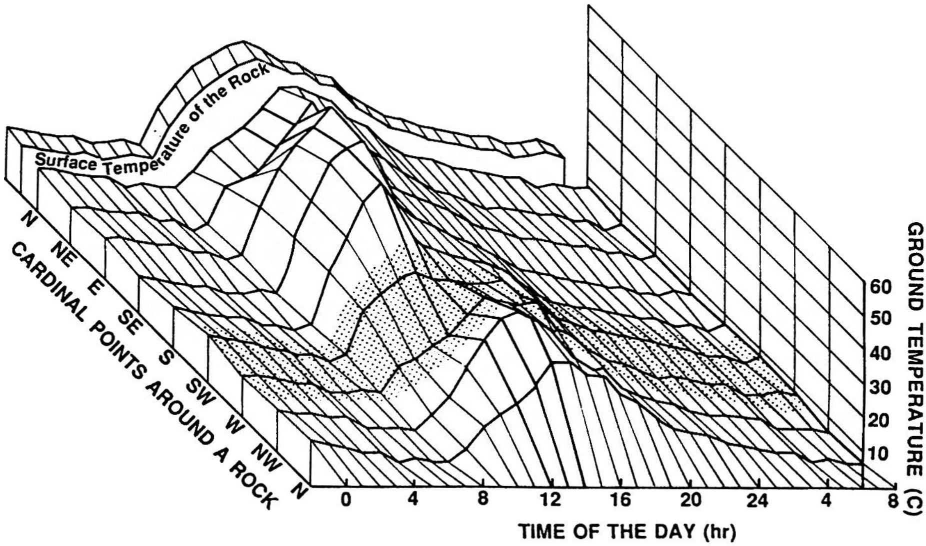

Fig. 3. 24-hourly ground temperature measurements at eight cardinal points around a rock with a chick refuge located at Cerro Negro nesting site. Shaded area indicates temperature within the actual refuge located on the S-W side of the rock (see Fig. 1B).

would enable chicks to avoid their chilling effect.

Compared with the open exposed incubation/brooding scrape, T_G's of the chick rock refuge was much lower between 10:00 and 17:00 h ($\bar{x}$ = 34 vs 51° C). At 13:00 h when the exposed scrape reached its maximal T_G (58°C), the refuge T_G was 22°C lower (36°C). Refuge and incubation/brooding scrape T_G's were nearly equal from 23:00 to 09:00 h.

DISCUSSION

Results supported our contention that refuges at the SW side of small rocks

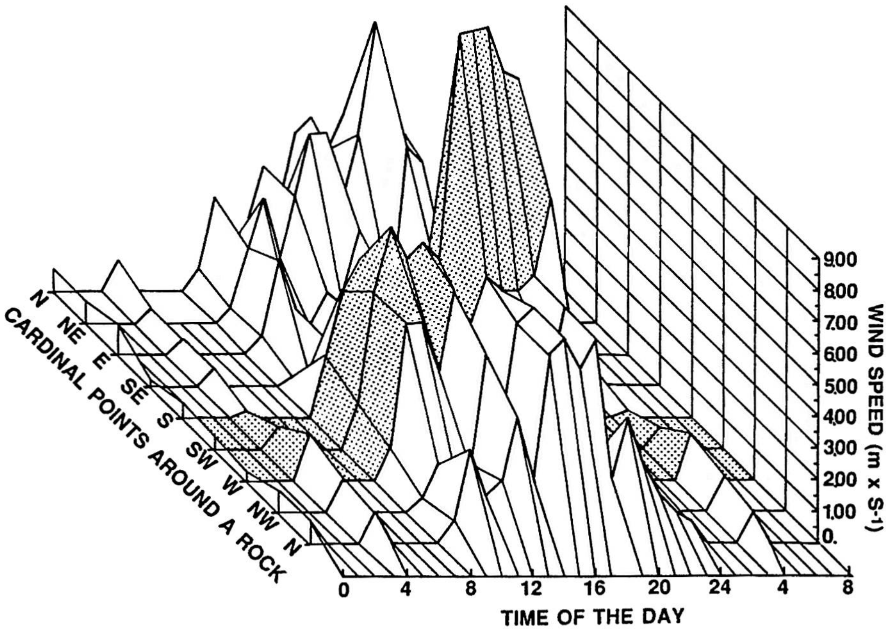

Fig. 4. 24-hourly wind velocity measurements at eight cardinal points around a rock with a chick refuge located at Cerro Negro nesting site. Shaded area indicates wind velocity within the refuge located on the S-W side of the rock (see Fig. 1B).

offer more favorable microclimatic conditions, specifically T_G and wind, for small unattended Gray Gull chicks than occur in the open exposed areas where adults incubate and brood. We focused on T_G for several reasons: (1) Bartholomew and Dawson (1979) emphasized T_G in their study of Heermann's Gulls (*L. heermanni*) which nests on desert islands in Baja, California and have nearly the same color and morphology as do Gray Gulls; (2) T_A varies in the same way as T_G in the Cerro Negro nesting site; (3) and though other microclimatic factors are known to affect animals' body temperature, the sky over the Atacama during nesting (December - February) is clear, except on a few foggy mornings, and the sun is almost directly overhead.

All active and inactive nesting sites we have observed during the past seven years are charcterized by having numerous small rocks strewn on the surface. We believe that Gray Gulls select these sites over other areas which are devoid of rocks, but may be closer to the coast, because of the microclimatic features associated with the rocks. Since young chicks are small, covered with light-colored down which has relatively fixed thermal conductance, they are far less homeothermic than adults. Consequently, they must rely on microclimatic advantages offered by the small rocks. Data in Guerra *et al.* (1988a) indicate that the chick refuges in dry channels offer similar microclimatic advantages. However, the channels are less common throughout the Atacama and used less frequently by chicks than the rocks.

Since the rock refuges provide much lower T_G's during the hottest period of the day, a logical question arises: why do not adults incubate and brood next to the SW side of the rocks? We believe that rocks are too small to afford adults protection, and that the wind velocities are not sufficient there or within the channels for adults to cool convectively. Their dark plumage and ability to erect feathers enables them to exploit the higher winds in the open for convective thermoregulation.

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SUMMARY

Gray gulls, *Larus modestus*, nest in the pampas of the Atacama Desert of northern Chile 35 - 100 km from the coast where small rocks provide favorable microclimate for their chicks. Unattednded chicks find partial refuge from the high ground and air temperatures during the day at the SW side of small rocks. Compared with more exposed areas, ground temperature in the chick refuge averages 17°C lower (x = 34 vs 51°C). At night, refuges shelter the chicks from the cold-dry winds from the Andes.

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SAMENVATTING

Larus modestus broedt in de pampas van de Atacama-woestijn in noord Chili, 35 tot 100 km van de kust. Kleine rotsblokken scheppen hier een gunstig microklimaat voor de kuikens. Deze vinden aldus aan de zuidwestkant van deze rotsen een schuilplaats die hen gedurende de dag gedeeltelijk beschutting biedt tegen de hoge grond- en luchttemperatuur. Vergeleken met meer open plaatsen, is de temperatuur in deze schuilplaatsen gemiddeld 17°C lager (x = 34 tegenover 51°C). 's Nachts bieden dezelfde schuilplaatsen bescherming aan de jongen tegen de koude en droge wind die vanuit de Andes komt.

RESUME

Le Goéland gris, *Larus modestus*, niche dans les pampas du désert d'Atacama dans le nord du Chili, à 35 - 100 km de la côte. De petits rochers y créent un microclimat favorable à leurs poussins. Non couverts par leurs parents, ceux-ci se protègent partiellement des hautes températures diurnes de l'air et du sol en s'abritant au côté sud-ouest de petits rochers. Par comparaison avec des zones exposées au soleil, la température au sol est, en moyenne, de 17° C plus basse dans ces refuges (x = 34°C pour 51°C au soleil). La nuit, ces abris protègent les poussins des vents andins, secs et froids.

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