PROGENICIDE IN DOUBLE-CRESTED CORMORANTS

DOUGLAS SIEGEL-CAUSEY

Adult Double-crested Cormorants (*Phalacrocorax auritus*) have been known to attack (but rarely kill) strange, sick, or dying cormorant chicks (Lewis, H.L., The natural history of the Double-crested Cormorant, Ru-Mi-Lou Books, Ottawa, 1929). During the first week of July 1975, on Mandarte Island, British Columbia, Canada, I observed five adult cormorants killing their own chicks.

The Double-crested Cormorant colony on Mandarte Island was composed of eight groups totaling 544 nesting pairs. One group, on the southern tip of the island, was a compact, isolated cluster of 43 nests containing 143 chicks. During the week of 3 July 1975, 46 chicks died (32%): 16 of these were by parental attack (see Table 1). The weekly mortality rate never exceeded 5% in the other groups during this period, and I noticed no unusual occurrences that might account for the high chick mortality in this group.

Adults were identified by several characters, but for this report I considered only banded birds. Sexes were determined through behavior (i.e. courtship displays, position during copulation, etc.). Parents were identified through long-term observations of the nests—unless the birds were positively recognized by the above means, and were observed courting, copulating, incubating, and sitting at the same nest, they were not considered true parents. Because cormorants are sensitive to intrusions, the colonies were never entered, and human disturbance was minimized.

Observations through binoculars and a 45× telescope, and later examination of photographs made during this period, confirmed the method by which parents killed their chicks. In all cases a parent grasped a chick and shook very quickly for about two seconds, and then paused about three seconds. This sequence was repeated until the chick became still. None of the chicks in the nests fled while their sibs were being strangled: all eventually perished. In two nests, B and

TABLE 1. Characteristics of nests and occupants where cormorant parents killed their young.

Date (1975)	Nest	Number of chicks killed	Age of chicks (weeks)	Sex of killer parent	Age of parent (years)
4 July	A	2	3	M	3
5 July	B	4	3	?	4
6 July	C	3	4	M	5
7 July	D	3	5	M	3
7 July	E	4	4	F	3

C, the dead chicks were incorporated into the nest structure. The killer worked the beak and head into the interstices and draped the body over the rim of the nest. All the nests were abandoned by the next week and the adult pairs were not seen again that season.

I know of no report of parent cormorants killing their own offspring. The affected nests did not differ from the rest of the group in any way that I could see (i.e., substrate slope, age of nest, or nearest neighbor distance). On Mandarte Island, cormorants breed as early as two years old and banding results indicated the killer parents to be young. Their nests were in a group which is the most recent in the colony (van de Veen, H. E., Breeding biology and demography of the Double-crested Cormorant, Univ. Groningen, Holland, 1973). I speculate that parental inexperience and aberrant chick behavior (caused perhaps by disease or pollution) elicited parental responses usually directed toward strange chicks. In the absence of data to support this, I cannot explain why parents would visit such destruction upon their progeny.

VOCALIZATION DURING INHALATION IN A NIGHTJAR

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The song of the Eurasian Nightjar (*Caprimulgus europaeus*) is a loud, low-pitched trill comprised of 25 to 40 pulses of sound per second. Nightjars can sing for several minutes during which the interval between pulses never exceeds 40 ms. This presents two complementary problems: (1) how do the birds get enough air to vocalize for so long and (2) how do they get oxygen while vocalizing? A number of birds produce longer vocalizations than one can reasonably expect a small respiratory system to sustain in a single exhalation. Calder (1970) proposed that they did this by using "mini-breaths," i.e., very rapid, very shallow breaths with one exhalation for each sound pulse (see also Brackenbury 1978a, b). However, he pointed out that "mini-breaths" could have little, if any, respiratory function, i.e., they will not prevent oxygen depletion of the lung's gases. Thus, although they might explain Calder's 27-s Canary (*Serinus canaria*) song, it seems unlikely that they could permit the 8-min burst of continuous vocalization that I recorded for one nightjar. In this paper I present inferential evidence for the hypothesis that nightjars can sustain very long vocalizations by continuing to sing while inhaling.

STUDY AREAS AND METHODS

I recorded 11 songs from four nightjars in Sussex and Buckinghamshire, England with a Sennheiser directional microphone and a Stellavox SP 7 tape recorder. I examined the temporal patterns and power parame-
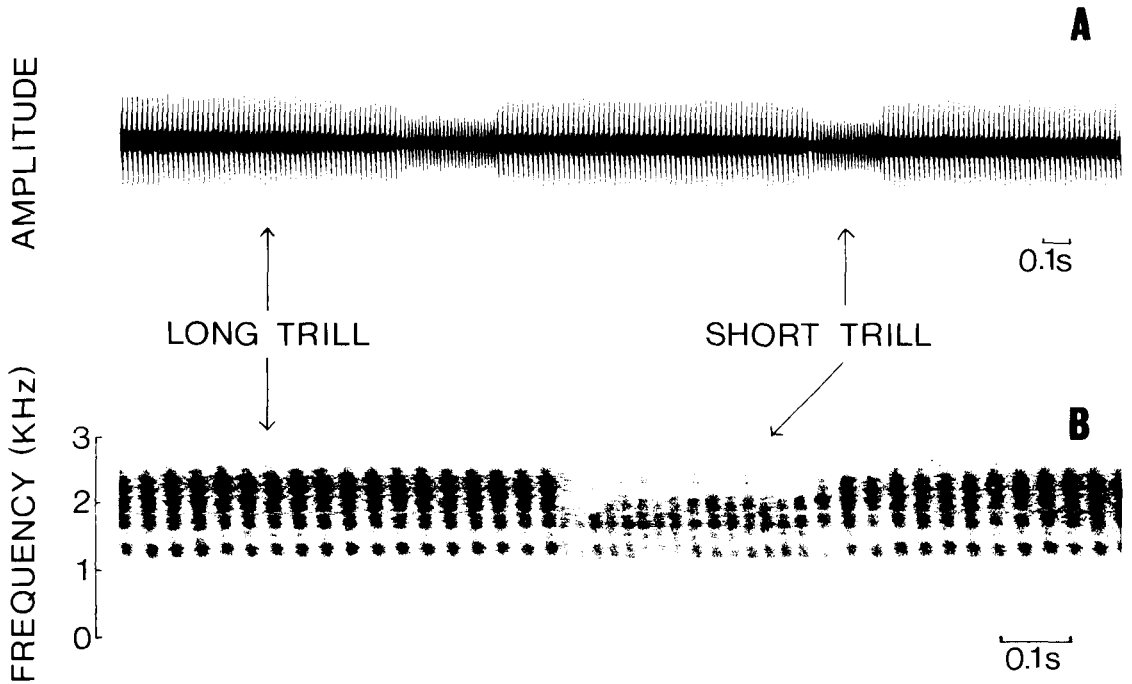
FIGURE 1. The long and short trills of a nightjar song. A: an oscillogram showing that the short trills, which may be made during inhalation, have less amplitude and more sound pulses per second. The exact values of the amplitude scale are not known but it is a linear scale of volts. B: a sonogram that indicates that the frequency range of long and short trills is similar but that the high frequency components of the short trills seem to be attenuated.

ters by playing the songs into a 50 mm/s strip recording oscillograph after filtering out noise below 1 kHz. Frequency parameters were measured from wideband sonograms made on a Kay Electric Co. 6061B sonagraph. Statistical analyses were based on a 40-s sample randomly selected from each recording.

RESULTS

The song consists of two alternating parts: a long trill that lasts from 0.3 to 10.8 s ($\bar{x}$ = 2.7) and short trill that deviates relatively little from a mean of 0.5 s (Fig. 1, Table 1). I hypothesize that these short trills are made during inhalation. Their mean duration is in the middle of the range one would predict knowing the breathing rate of a nightjar at rest (0.7–1.3 breaths/s; Peiponen 1965, 1966). The amplitude of the long trill averages 2.9 times greater than that of the preceding short trill ($P \ll .001$, t-test). The emphasized frequency of the long trill pulses is not measurably different from that of the short trill, but the high frequency components of the short trill pulses appear to be attenuated. The average number of pulses per second is significantly greater ($P \ll .001$, t-test) during short trills (40/s) than during long trills (27/s).

DISCUSSION

It is not possible to definitely say if these observations support the hypothesis because our understanding of syringeal mechanisms in general, and of caprimulgiform syrinxes in particular, is too limited. At least the data do not contradict the most widely accepted model of syringeal mechanisms, that of Greenewalt (1968).

It is widely accepted that avian vocalizations occur only during exhalation, but this idea is largely based on a limited amount of work on dead birds (Miskimen 1951, Chamberlain et al. 1968). Working with live birds, Gaunt et al. (1973) confirmed this observation for the distress calls of Starlings (Sturnus vulgaris), but Gaunt and Gaunt (1977) mentioned that at the end of a chicken's (Gallus gallus) crow "inhalation may be accompanied by a distinct, sometimes quite loud, wheezing sound." Gaunt (pers. comm.) has also noted a vocalization being accompanied by inhalation in the Turtle Dove (Streptopelia turtur). Kneutgen (1969) found a correspondence between song form and breathing in a thrush, the White-rumped Shama (Copsychus malabaricus), which he felt indicated vocalization during inhalation.

TABLE 1. Characteristics that distinguish the long and short trills of an Eurasian Nightjar song.

	Short trills			Long trills			Trill pairs
	$\bar{x}$	S.E.	Range	$\bar{x}$	S.E.	Range	N
Duration (s)	0.53	0.01	0.24–1.10	2.66	0.11	0.30–10.80	138
Pulse rate (N/s)	40.2	0.08	40.0–45.0	27.2	0.09	25.0–30.0	138
Amplitude (relative units)	1	—	—	2.9	0.14	1.4–5.1	45

In conclusion, it seems impossible that a nightjar could sing for eight minutes without replenishing its oxygen. It seems equally unlikely that sufficient oxygen could be acquired during the 25–40 ms gap between sound pulses. The temporal and amplitude pattern of their song suggests that nightjars may sustain long vocalizations by singing one part of their song, the short trill, during inhalation.

Why sing for so long? I have preliminary data that suggest there is individual variation in the maximum length of song; this implies that song length may have evolved under sexual selection or as an assessment cue of fighting ability.

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METABOLISM AND THERMOREGULATION IN HATCHLING WESTERN GULLS

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Parental attentiveness provides hatchlings of many precocial and semiprecocial birds with a large measure of protection from the vagaries of the thermal environment. Nonetheless some of these species differ in thermoregulatory capacity of newly hatched chicks, in correlation with climatic conditions during the breeding season. For example, hatchling ducks of species breeding exclusively in the arctic and subarctic tend to have better control of body temperature in cool environments than do those of species with wider and more southerly distributions (Koskimies and Lahti 1964). A similar pattern seems to exist for hatchling gulls. Black-headed Gulls (*Larus ridibundus*) and Ring-billed Gulls (*L. delawarensis*) can approximately double their rates of heat production over basal levels when subjected to cold stress on the day of hatching (Kespaik and Davydov 1966, Dawson et al. 1976). In contrast, Laughing Gulls (*L. atricilla*), which appear to breed under somewhat warmer conditions, can increase theirs by only 50% (Dawson et al. 1972). The range of metabolic capacity among hatchling gulls may be even greater than these values indicate, for the genus *Larus* includes more than 30 species whose respective breeding ranges embrace a latitudinal span from the arctic to the subantarctic. As opportunities arise, we are attempting to assess the extent of differences in thermoregulatory capacities among hatchlings of these species. We report here observations on chicks representing the subspecies of Western Gull (*Larus occidentalis livens*) breeding in the Gulf of California, Mexico.

Our experimental subjects were obtained from Isla Partida, Baja California Norte, Mexico (28°54'N, 113°3'W) on 29 April–1 May 1976. During this period, nights were cool, days were warm, and solar radiation was intense. Conditions were similar to those on nearby Isla Rasa (10 km SE), where we had made micrometeorological measurements from 18–28 April 1976, in connection with studies of Heermann's Gulls (*L. heermanni*). Daily minimal and maximal temperatures at nest height on Isla Rasa averaged 12.9°C (range, 8.4–16.7°C) and 32.2°C (range, 28.7–34.7°C), respectively. Intensity of solar radiation reached 1036 W/m² at midday on 19 April 1976, and was near this level on several subsequent days.

Following collection, newly hatched Western Gulls were transferred for study to the nearby R/V *Dolphin*, and then exposed to constant ambient temperatures (T_a) between 16° and 35.3°C for two-hour periods. These concluded with measurement of oxygen con-