Vulnerability of Eggs and Young of the Blackish Nightjar (*Caprimulgus nigrescens*) in Suriname

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Crepuscular and nocturnal caprimulgids (nighthawks and nightjars) form a particular group of insectivorous birds (Junge 1964). During daylight hours, they roost on the ground or low in vegetation, often in open situations exposed to full sunshine. During twilight and nighttime hours they become active, feeding entirely on night-flying insects. Their eggs are laid on the ground. Clutches consist of 1 or 2 eggs incubated by male and female, and both care for the young.

We studied the reproductive biology of the Blackish Nightjar (*Caprimulgus nigrescens*) in Suriname during the period 1979-1982. Aspects of the reproductive behavior of caprimulgids that directly influence their breeding success have been discussed only occasionally (Skutch 1972, Oniki 1979). One such important aspect is their habit of nesting directly on the ground. We report here about the vulnerability of the ground-bound eggs and young of *C. nigrescens* with regard to such proximate factors as solar radiation, precipitation, and predation.

C. nigrescens is a small (22 cm), dark-colored, sexually dimorphic, South American nightjar (Ingels and Ribot 1982). It occurs throughout the Amazon basin and exhibits a wide ecological tolerance. It is common in Suriname, where it prefers stony areas and rocky outcrops in savannas and forests (Ingels and Ribot 1983).

Our study site comprised the two granite outcrops near Voltzberg (4°40′N, 56°11′W) in the Raleigh Falls-Voltzberg nature reserve on the Coppename River managed by STINASU (Foundation for Nature Preservation in Suriname) (Ingels and Ribot 1983). There, up to 20 pairs breed yearly on approximately 5 ha of granite outcrops, which are covered with scattered vegetation, mainly ground orchids, bromeliads (mostly *Pitcairnia nuda*), and *Clusia* bushes, and are surrounded entirely by primary lowland rainforest. This nature reserve is situated in a part of Suriname with an average annual rainfall of 225-250 cm. The average monthly distribution of precipitation and insolation over a year during the period 1931-1960 are given in Fig. 1a (van Scherpenzeel 1977).

In Suriname, the clutch size of *C. nigrescens* is always one egg (Haverschmidt 1968, Ingels 1981). The egg is laid directly on the open, bare, granite rock or on litter near vegetation; there is no attempt to build a nest. Over the period 1979-1982, we found 69 "nests" (= eggs) on the granite outcrops. The monthly distribution is given in Fig. 1b. The two breeding seasons of *C. nigrescens* coincide with the short dry season (SDS, February-March, with frequent showers and cloudy skies) and the long dry season (LDS, half of August-November, with occasional showers and open, cloudless skies).

Nesting sites are chosen mainly on the open, bare, granite rock during the SDS and near vegetation during the LDS (Fig. 1b). The difference is significant ($\chi^2 = 22.55$, df = 1, $P < 0.001$). On open, bare, granite rock, eggs are laid in small depressions, 2-3 cm deep (Fig. 2a). Near vegetation, eggs are laid on a layer of humus and dead plant material, which is always present there (Fig. 2b). Eggs are cryptically colored and slightly glossy, with a creamish to pinkish buff ground color and brown spots overlaying brownish spots and blotches. Irregular markings of different

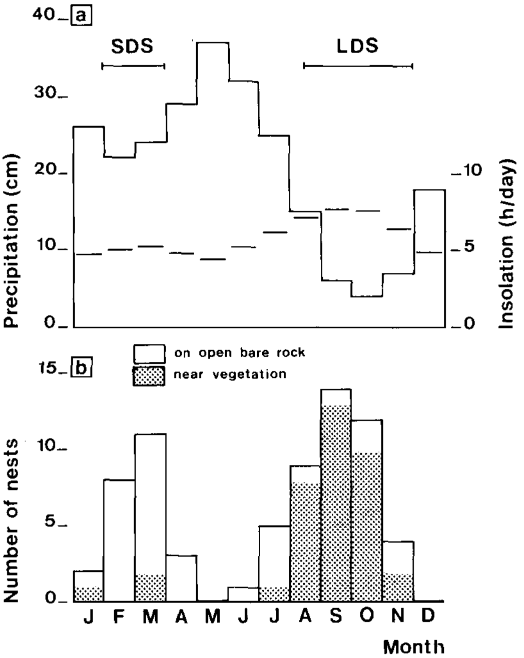

Fig. 1. Average monthly distribution over a year of (**a**) precipitation (in cm) (unbroken histogram) and insolation (in h/day) (broken histogram) at Voltzberg during the period 1931-1960 (SDS: short dry season; LDS: long dry season), and (**b**) 69 nests (= eggs) of *C. nigrescens* found at the study site during the period 1979-1982 (white: eggs found on open, bare, granite rock; stippled: eggs found on litter near vegetation).

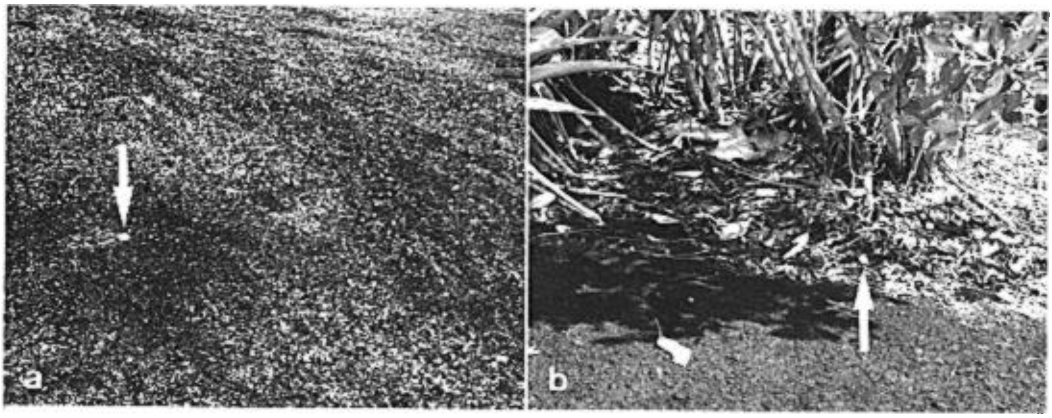

Fig. 2. Typical nest sites of *C. nigrescens*. The egg (arrow) is laid (**a**) in a slight depression of the bare granite rock, exposed to full sunshine, or (**b**) on litter of dead plant material near vegetation, shaded by overhanging branches of *Clusia* bushes.

shades and color intensities are fairly uniformly distributed over the entire egg (Ingels 1981). Average egg dimensions are 18.8 × 25.4 mm ($n = 18$, range = 17.3–20.3 × 23.9–27.2 mm, SD = 0.4 × 0.7 mm).

We determined temperatures in an exposed egg by measuring with a portable Philips PM2517X multimeter the resistance of a Uni-Curve thermistor (type UUA35J1 of Fenwal Electronics Inc., typical resistance 5,000 ohms at 25°C and 0.2°C tolerance in the range 0° to 80°C) mounted inside the egg (Ingels and Ribot 1983). On sunny, windless days, temperatures in an egg exposed on open, bare, granite rock reach maxima of 44–50°C after periods of 20–30 min of continuous exposure to full sunshine. We observed that after one such exposure to temperatures of over 44°C for about 15 min, two heavily incubated eggs failed to hatch following the normal incubation period and that the embryos were addled. On sunny but windy days, air convection around the egg keeps it substantially cooler than on windless days, with maximum temperatures never exceeding 43°C, even after prolonged exposure (>30 min). We found that after several such exposures of about 15 min each, three eggs hatched normally. Therefore, we believe that heating of exposed eggs to temperatures in the range 47° ± 3°C, even for restricted periods, is detrimental to *C. nigrescens* embryos (cf. Drent 1975, Bennett and Dawson 1979, Bennett et al. 1981).

Ambient air temperatures above the granite outcrops and rock temperatures were determined during sunny, windless days by measuring simultaneously the resistance of a thermistor attached to a shaded, 2-m-high branch of a *Clusia* bush and of a thermistor fixed 5 cm deep in the granite rock. Air temperatures typically reached maxima around 39°C (between 1400 and 1500), and rock temperatures reached 44°C (between 1500 and 1600) (Ingels and Ribot 1983). The deep-body temperature (DBT) of adult *C. nigrescens*, mist-netted between 0600 and 0800 when ambient air temperatures were 22°–26°C, was determined by measuring the resistance of a thermistor introduced anally approximately 2 cm deep and ranged between 38.8° and 39.8°C ($n = 5$, $\bar{x} = 39.3$°C, SD = 0.2°C). The DBT of caprimulgids is lower than that of other birds of comparable size and weight (McNab 1966, Oniki 1972). During a sunny, windless day, temperatures in an incubated egg, determined by measuring the resistance of a thermistor mounted inside, vary between 35.5° (0830 and 1800) and 39.5°C (1430), with corresponding ambient air temperatures of approximately 27° and 38°C, respectively. Obviously, the uninterrupted incubation during daylight hours protects the egg against lethal overheating.

The depressions in the granite rock in which the egg is laid quickly fill with water during showers. Eggs are frequently partly immersed or sometimes completely so, but never for a long time, as rainwater evaporates quickly on the warm granite rock. Adults continue to cover (= incubate ?) an immersed egg. We found that such eggs do hatch afterward. We also observed, however, that a hatchling drowned in a pipped egg lying in a depression flooded by rain.

Because of their irregular, blackish color pattern, adult *C. nigrescens* incubating on the dark-colored, bare granite are inconspicuous. Eggs deposited in depressions in bare granite rock are conspicuous when exposed (Fig. 2a) and should be easy for predators relying upon sight to find. The open situation around the nest site, however, makes approaching predators easily visible, although wandering human intruders and predators scaring an adult off its egg for periods of over a half hour during sunny, windless days could cause the egg to become overheated and the embryo to die. Nevertheless, *C. nigrescens* prefers to lay its egg in open situations during the SDS, when showers and cloudy skies are frequent, so the advantages of occupying an open nest site on bare rock (i.e. a reduction of predatory losses) should compensate for the rare chance of an overheated egg or a chick drowned while hatching.

Eggs deposited near vegetation blend rather well with the litter of dead plant material (Fig. 2b). During clear weather, such nest sites are shaded by overhanging vegetation, especially from the vertical midday sun. Uncovered eggs are therefore rarely reached by direct sunshine. During the afternoon (1200–1600) of sunny, windless days, temperatures inside an exposed egg in the shadow of a *Clusia* bush range around 35° ± 4°C, so that overheating is no direct threat.

Because of their cryptic color pattern, adult *C. nigrescens* incubating near vegetation blend well with the surrounding litter. As they always face the open rock, they are likely to be surprised only by predators approaching from inside the vegetation.

C. nigrescens choose a nest site in a shady situation near *Clusia* bushes during the LDS when showers are rare and solar radiation is intense, so the advantages of occupying a shaded nest site (i.e. a reduction of losses by lethal overheating) should compensate for the risk of loosing eggs to predators active in or around vegetation.

Unsuccessful breeding attempts during the egg phase typically end either with the egg found deserted or broken and the contents addled after prolonged incubation (lethal overheating) for open SDS nest sites or with the egg simply vanishing (predation) for shaded LDS nest sites near vegetation.

It is difficult to learn just when the single egg of *C. nigrescens* is laid; therefore, the exact incubation period is unknown. From fresh egg weight and weight loss during incubation, however, we estimate it to be 17 ± 1 days (Ingels et al. MS). At hatching, the semiprecocial young have open eyes and are covered with cryptically colored down. Both on open granite rock and on litter, they blend well with their surroundings. From the first day, young can move over distances of several meters by hopping over the ground, which they do mostly in response to special call notes of the adults. Adults alight on the ground some distance away and call the youngster, which hops toward them to be fed or brooded. Even when only a few days old, the young have a surprising capacity to surmount obstacles (Skutch 1972). Therefore, they are able to escape from perilous situations such as excessive insolation or rainfall.

Caprimulgids and their young have special defences against overheating (Lasiewski 1969, and references therein). They have a lower basal metabolic rate than most birds of comparable size and weight and a very effective and extensive capacity for evaporative cooling by gular fluttering (Cowles and Dawson 1951). The rate of heat loss is highest at ambient temperatures exceeding the DBT. The caprimulgids' ability to dissipate significantly more heat than they produce permits them to remain substantially cooler than their surroundings at high ambient temperatures.

A 3-day-old *C. nigrescens* exposed to full sunshine on open granite rock started gular fluttering within 3–5 min. After prolonged exposure (>10 min), it started to utter chirping distress calls and to hop in random directions, apparently in search of a shaded resting site. We measured its DBT continuously, and it never exceeded 40.5°C. When placed in the shadow of a *Clusia* bush, it stopped chirping and gular fluttering and quieted to the crouched motionless posture typical of roosting adults.

Adults brood young on open rock or near *Clusia* bushes, during both the SDS and LDS. Individual adults with their young, however, are found in quite different locations from day to day. Adults, brooding under the stress of intense solar radiation, help the young to dissipate heat. Although young exposed accidentally to full sunshine are able to cope for a limited period with the additional heat load, they need to use this ability only as an effective last resort.

Ground-bound young *C. nigrescens* are threatened directly by rainy weather, especially at night. Moreover, although rainy seasons increase the availability of insect food (Ricklefs 1975), rainy weather affects the time available for adults to collect food. Rainfall restricts the activity of airborne insects and forces parents to brood their young to prevent chilling. The ability of young to move over considerable distances, however, enables them to find drier sites during rainy periods. They choose places near vegetation, where a substratum of dead plant material a few centimeters thick absorbs rainwater, or well-drained places on slightly sloping, bare rock. Even pouring rain is no real hazard to a chick when brooded by an adult. Only exposed young become bedraggled during severe showers.

Skutch (1949) calculated that 4.5 h/day is a minimum for a pair of neotropical, insectivorous birds to collect sufficient food for one chick. For *C. nigrescens*, the approximately 12-h nights all year round in Suriname account reasonably well for the feeding of one young and for meeting the adults' basic needs for food and body care, even when adverse weather restricts nightly activities (Ingels et al. MS).

Obviously, in *C. nigrescens*, eggs are more vulnerable than young, not only to solar radiation and precipitation but also to predation by a great variety of reptiles, birds, and mammals (Skutch 1972). For the 14 eggs, the incubation of which we followed, we found a loss of 64 ± 7% before hatching. Uncertainty results from our failure to locate some young after hatching. Because of the mobility of the young from the day they hatch, it is difficult to learn about their final fate. Nevertheless, after comparing the number of pairs with a fledgling at the end of a breeding season with the total number of pairs that occupied the granite outcrops during that season, we assess a loss of young of 21 ± 8%. Uncertainty in this case results from pairs that had a replacement clutch or left the area after an unsuccessful attempt to reproduce. Thus, the total nesting success is 28 ± 15%.

The greater vulnerability of eggs than young is reflected also in the behavior near the nest site of incubating or brooding *C. nigrescens* when confronted by an intruder. Injury-feigning displays are given readily; the parents grovel on the ground with drooping wings, trying to lure the intruder away from the egg or young. Such displays are given more frequently before the egg hatches than afterwards, probably because the egg is more vulnerable than a young nightjar when exposed. When incubating, the adult sits steadily; it leaves the egg only when approached within 8-5 m and then flies off directly or after displaying. When brooding, it shoves aside the youngster when approached within 12-8 m and then grovels discreetly farther away before flying off.

From our observations, we can conclude that throughout the breeding cycle of *C. nigrescens,* the egg phase is the most vulnerable period. The loss of eggs is three times higher than the loss of young.

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