in our study was very large and well constructed, and the female spent much time in the nest cup in an incubating position. These birds may have been two-year-olds since the male had a slight cinnamon tinge on the nape, which Ospreys are said to lose at about 18 months of age (Bent 1937).

DISCUSSION

We found no significant difference in the pattern or duration of activities of birds using the two habitats during any period of the reproductive cycle. Furthermore, we noted little variation among pairs for each activity in both habitats. The time/activity budget determined in our study for adults up to the time the young leave the nest is similar to those of populations studied by Green (1976), Stinson (1978) and Levenson (1979) in widely different habitats and geographic areas.

Division of labor between the sexes was the same in birds using both habitats. A similar close parallel, with respect to roles, exists with the other studies. The major task of the male is to provide fish to the female and young. If males must conserve energy for foraging, this might explain, in part, why they spend so much time perching when not foraging.

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THE THERMAL NEST ENVIRONMENT AND PARENTAL BEHAVIOR OF A BURROWING BIRD, THE BANK SWALLOW

JANET H. ELLIS

Avian embryos can develop only in a relatively warm and stable environment (White and Kinney 1974). Adult birds must therefore modify the environment around the egg to promote its proper development. The amount of time and energy that parent birds must devote to this activity strongly depends upon ambient temperatures around the nest. The burrow environment is thermally more stable than most nesting habitats, protecting birds from temperature extremes (White et al. 1978). However, burrow temperatures are continuously lower than the "relatively warm" environment required for avian embryonic development. Parental nest attentiveness of burrowing birds hence must reflect the low temperatures of the nesting cavity. I examine here the thermal nest environment and incubation habits used by one burrowing species, the Bank Swallow (*Riparia riparia*).

Bank Swallows are the smallest North American swallows (15 g). They nest in burrows dug in sand or gravel banks, extending 0.3–1.0 m or more into the soil (Bent 1942). Nests are constructed of loosely woven grasses and feathers. The species is circumpolar in distribution, breeding throughout the Northern Hemisphere.

METHODS

I excavated an observation pit (Beyer 1938) behind a swallow colony on a cliff that faced west-southwest near Missoula, Montana (46°52′N, 114°01′W). A cardboard cone with a small window was then placed against the nesting chamber of four burrows. Care was taken to seal the spaces around the cone to prevent drafts between the observation pit and the burrow. I kept the pit dark to minimize disturbance of the birds. Temperatures of incubation, the burrow and the outside air were measured using a portable tele-thermometer. A thermistor probe inserted into a silicone-filled Bank Swallow egg monitored incubation temperatures (Calder 1971). Each thermistor egg was substituted for one egg in each nest to keep clutch size constant. A second probe suspended above the nest in each nesting chamber measured burrow temperature. Outside air temperatures were measured by a probe located near the cliff face. All probes were calibrated with a National Bureau of Standards thermometer before and after field experiments. Temperatures were read to the nearest 0.1°C.

I began recording data 20 min after entering the observation pit, which allowed displaced birds to return to their nests. Temperatures were recorded at 5-min intervals during observation periods. It took me approximately 3.5 days to gather one 24-h day of observations. I watched birds a total of 67 h between 23 June and 7 July 1979. All temperatures used in analysis as incubation temperatures are those recorded at least 5 min after a parent bird began sitting on the nest.

RESULTS AND DISCUSSION

The number of observation hours per nest varied from 3.0 h for nest 3 to 65.3 h for nest 2 (Table 1). Eggs hatched

TABLE 1. Incubation, burrow and outside air temperatures (°C), number (n) of observations and total hours of observation (h) in four Bank Swallow nests.

Nest	1	2	3	4	All
Incubation					
Overall mean (SD)	34.5 (2.1)	34.5 (1.3)	31.2 (1.3)	29.9 (1.0)	33.7 (2.1)
n	504	783	36	148	1,471
Daytime (SD)	34.4 (2.1)	34.0 (1.4)	31.2 (1.3)	29.4 (0.9)	34.0 (2.0)
n	383	553	36	29	1,001
Nighttime (SD)	34.8 (2.1)	34.0 (1.0)	—	30.0 (1.0)	33.2 (2.3)
n	121	230	—	119	470
Cavity					
Range	15.3–24.9	15.0–24.1	21.1–23.5	19.9–24.8	15.0–24.9
Mean (SD)	20.8 (2.2)	19.4 (2.0)	22.1 (0.5)	22.5 (1.2)	20.3 (2.2)
n	504	783	36	148	1,471
Outside (cliff face)					
Range	8.9–46.7	2.4–46.7	24.0–38.9	12.0–35.0	2.4–46.7
n	504	783	36	148	1,471
Hours of observation	42.0	65.3	3.0	12.3	67.0 (overall)

in nests 1 and 4. Birds incubated eggs in nest 2 for more than 14 observation days before abandoning their nest. Eggs in this nest proved to be infertile. Nest 3 was abandoned shortly after four eggs (an average full clutch) were laid.

The mean temperature of incubated eggs was 33.7°C ± 2.1 SD (Table 1). This temperature is lower than the incubation temperature (35.0°C) reported for Bank Swallows by Huggins (1941). However, it is within the range reported for other passerine species (Huggins 1941, Drent 1976). Mean incubation temperatures of eggs in the individual nests studied were significantly different from each other (Mann-Whitney U-test, $P < 0.001$). Although young hatched in both nests 1 and 4, these nests represented the two extreme average incubation temperatures, 34.5°C ± 2.1 SD and 29.9 ± 1.0 SD respectively. This difference in incubation temperatures between nests may reflect differences in how tightly parent birds sat on dummy eggs.

The average daytime incubation temperature for eggs in all nests was 34.0°C ± 2.0 SD, while that for night hours was 33.2°C ± 2.3 SD (Table 1). Daytime incubation temperatures were significantly higher than nighttime temperatures in nest 4 eggs only (Mann-Whitney U-test, $P < 0.001$). The lowest egg temperature recorded while incubating birds were off the nest was 21.1°C.

Nest thermal environment. The mean burrow depth in this study was 0.54 m ± 0.1 SD. Nests 1 and 2 had two entrances to the nesting chamber; nests 3 and 4 had only one.

Cavity temperatures ranged from 15.0°C to 24.9°C ($\bar{x}$ = 20.3°C ± 2.2; Table 1). Temperatures recorded outside the burrow near the cliff face ranged from 2.4°C to 46.7°C. The National Weather Service recorded corresponding temperatures between 3°C and 34°C for this area during the study, indicating cliff face temperatures were inflated due to insolation. Although the burrow environment was affected by outside air temperatures, it was thermally more stable (Table 1). The relationship between burrow and cliff face temperatures is described by the regression equation $Tb = 0.18\,(Tc) + 16.1$ [where Tb is the burrow temperature (°C) and Tc is the cliff face temperature (°C)] (n = 1,471; $r = 0.75$; $P < 0.001$). This relationship can perhaps be improved in a multiple regression analysis considering such factors as burrow diameter, length and the number of nest entrances (Coulombe 1971).

Incubation behavior. The mean constancy of incubation (% of observation time the bird was on the nest) was 75.9% ± 8.7 (Table 2). The nest with the highest constancy of incubation (100%) had the lowest average incubation temperature (29.9°C). Young also hatched in a second nest with a lower constancy (84.5%) and the highest incubation temperature (34.5°C).

Skutch (1962) determined that in bird species with single parent incubation, constancy is between 60 and 80%. Eggs of birds that share incubation are generally attended continuously by one parent or the other (White and Kinney 1974). Although Bank Swallows share incubation, only females develop incubation patches, indicating that responsibilities for incubation may not be evenly divided (Petersen 1955). I witnessed one swallow replacing another

TABLE 2. Constancy of incubation, attentiveness and inattentiveness in Bank Swallows.

Nest	1	2	3	4	All
Constancy of incubation	84.5%	78.6%	40.4%	100%	75.9% ± 8.7 (SD)
Attentiveness (in minutes)					
Range	10–180	5–90	5–25	—	5–180
Mean (SD)	41.0 (36.9)	30.3 (19.1)	11.3 (6.7)	—	30.8 (26.2)
n	31	60	15	—	106
Inattentiveness (in minutes)					
Range	5–20	5–25	—	—	0–25
Mean (SD)	10.9 (5.6)	11.8 (5.7)	—	0	7.6 (6.6)*
n	47	82	—	—	—

* Mean and standard deviation values were obtained by averaging *mean* inattentiveness values because of the "0" reading for nest 4 eggs.

on the nest but because birds were not individually identified, I could not learn about possible role differences of the sexes.

Adult birds attended eggs from 5 to 180 min at a time (Table 2). Inattentive periods averaged 7.6 min ± 6.6 in the three nests with consistent incubation. Attentive and inattentive periods showed no significant relationship to time of day, burrow temperature and/or cliff face temperature (correlation coefficients, $P > 0.05$).

A burrow is a unique environment for a small bird to nest in as ambient temperatures are continuously below incubation temperatures. Perhaps if temperature data can be examined in light of other microclimatic conditions, a more complete picture can be drawn of the incubation habits of burrow nesting birds.

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BOTFLY (DIPTERA, MUSCIDAE) PARASITISM OF NESTLING APLOMADO FALCONS

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The genus *Philornis* contains flies whose larvae inhabit the nests and parasitize the nestlings of many Neotropical birds (Aldrich 1923, Hicks 1959, 1962). In 1977, I found a stick nest containing young Aplomado Falcons (*Falco femoralis*) all infested with *Philornis* larvae. The following description of this infestation is, to my knowledge, the first published report of *Philornis* in a falconiform nest and the first published description of a parasite of the Aplomado Falcon.

At least 17 species of *Philornis* flies have been described (H. R. Dodge, unpubl.). Most are nondescript, yellow-brown to black, slightly larger and stockier than the common housefly. The fourth wing vein bears a slight apical bend, which is the most obvious diagnostic feature of the genus (Aldrich 1923). *Philornis* has been collected in southern Texas, Mexico, Cuba, Jamaica, Trinidad, Puerto Rico, Florida, Panama, Costa Rica, Argentina, and Venezuela (Dodge 1955, 1968; Hicks 1959, 1962; Dodge and Aitken 1968). In nearly all cases, adult flies were first collected from nestling birds as larvae and then reared. Adult *Philornis* lay their eggs in birds' nests (Aldrich 1923). After hatching, larvae of most species burrow under the skin of the nestlings and feed on the hosts' blood (Aldrich 1923). Before pupating, larvae emerge through small apertures in the skin and fall to the floor of the nest. Pupation occurs within a cocoon formed from a salivary gland secretion and usually takes less than two weeks (Dodge, unpubl.). Known hosts are Neotropical landbirds, mostly passerines (listed in Dodge 1955, 1968; Hicks 1959, 1962; Dodge and Aitken 1968).

During March 1977, I began a study of the natural history of the Aplomado Falcon in eastern Mexico (Hector 1980). Seventeen falcon territories were located that year and the infested nest was the last one found (on 31 May). When I discovered this nest, only 6–12 larvae were apparent on each of the three nestlings, distributed mostly about the heads of the young birds (Fig. 1). A few larvae were embedded among the follicles of the growing remiges. On 7 June, larvae were evident at new locations on the nestlings, indicating that those initially seen had left their hosts to pupate, while others had now grown enough to be detectable.

The smallest falcon (250 g) was removed from the nest on 7 June and transported to a captive-breeding facility established by the Chihuahuan Desert Research Institute in Alpine, Texas. This nestling was raised in quarantine and all larvae were collected as they emerged. Of the 35 collected over a 14-day period, 15 were preserved as larvae and the remainder allowed to form pupae. Within hours after emerging from the falcon, the larvae quickly covered themselves with a whitish, foamy secretion that soon hardened to form a cocoon. Ten pupae were preserved. The surviving pupae were kept in small enclosures containing some local soil as a substrate. Approximately eight days later, adult flies appeared and were preserved. A sample of larvae, pupae and adult flies was then sent to the Systematic Entomology Laboratory (Beltsville, MD) for identification. The specimens could not be identified specifically because present keys for *Philornis* species are inadequate (Lloyd Knutson, pers. comm.).

This brood was the only one that appeared to be infested with larvae in 1977. Infestations, however, may not have been detected at other nests due to differences in degree of infestation and my failure to scrutinize the nestlings. Three three-to-four-week old falcons at a site examined in 1979 bore numerous scars, which I suspect were caused by *Philornis* larvae. As mentioned above, one of the infested nestlings bore 35 larvae although fewer than half this number were apparent when the nestlings were first inspected.