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Nesting of the Pectoral Sparrow (*Arremon taciturnus*) in Southeastern Peru

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ABSTRACT.—We report the first detailed account of the breeding biology of the Pectoral Sparrow (*Arremon taciturnus*). We found 15 dome nests, each containing two eggs in a spherical interior chamber. Eggs were variable in color, ranging from immaculate glossy white to white heavily spotted with brown. Incubation patterns were obtained for six nests for time spans that ranged from 1 to 15 days for a total of 28 days across nests. Incubation in all nests was solely by the female, spending an average of 57% (range = 20–65%) of daylight incubating, leaving the nest an average of 7.4 times per day (range = 4–7) with an average trip length of 46.4 min (range = 6–263 min.). Nest temperature averaged 29.2 ± 2.64° C when the female was incubating and decreased to 26.6 ± 2.43° C during incubation recess. Eggs in only two nests hatched and were monitored for 2 and 9 days. The male provided the young with 75% of the food. Nestlings gained an average of 2.53 g per day. Incubation, provisioning behavior, and egg coloration were similar to other species of *Arremon*; however, nest shape, location, and materials differ among species. *Received 17 January 2011. Accepted 3 June 2011.*

The genus *Arremon* is composed of 10 species, eight of which have published nest descriptions (Skutch 1954, Haverschmidt 1968, Tye and Tye 1992, Auer et al. 2007); four only have information about incubation and chick-rearing behavior (Skutch 1954, Martin 2002). The Pectoral Sparrow (*Arremon taciturnus*) is common throughout the Amazon rainforest from the eastern base of the Andes in Colombia, Brazil, Bolivia, and Peru to most of the Amazon rainforest in Venezuela, Guyana, Suriname, and Argentina (Hilty and Brown 1986). It is common and widely distributed, but little is known about its nesting biology with most of the information generated by sporadic observations (Snethlage 1935, Haverschmidt 1968).

Detailed nesting biology descriptions are fundamental to understanding variation in avian reproductive strategies, which can improve our understanding of the geographic diversity of avian reproductive traits and life history strategies (Auer et al. 2007). Nests and behaviors are useful to reconstruct phylogenetic relationships (Zyskowski and Prum 1999), and filling gaps in current knowledge becomes relevant, especially since the number of species in the genus *Arremon* is still being debated (Cadena and Cuervo 2010). Our objective was to provide detailed observations of the nesting biology of *Arremon taciturnus*, and to compare it with the available information for this and other species of the genus.

METHODS

Study Area.—This study was conducted in the foothills of Manu National Park, Cusco, Peru, near the Tono River (12° 57′ 58.2″ S; 71° 34′ 05.3″ W); the average annual temperature for the location is 24.4° C (range = 19.3–30.7° C). We searched for nests 6 days a week from 0600 to 1700 hrs (local standard time) between mid-August to mid-December in 2008 and 2009 covering 2 km^2 of forest at elevations between 800 and 1,100 m.

Nest and Eggs.—Once a nest was found, eggs were weighed to the nearest 0.05 g with a digital pocket Scale (FlipScale F2; My Weigh Inc., Kelowna, BC, Canada; http://www.myweigh.com) and measured to the nearest 0.1 mm with calipers. Two to three temperature sensors were placed in six of the nests. The first sensor was inside the nest directly under the eggs. A second sensor was placed outside the nest to record ambient temperature. An additional temperature sensor was placed inside a fresh egg in one of the nests; the sensor was introduced by drilling a small hole in the shell, and sealing it with super glue after the sensor had been added. All sensors measured temperature every minute and the information was stored on a U12 4-channel hobo data logger (Onset Computer Corporation, Pocas-

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set, MA, USA; http://www.onsetcomp.com). This allowed reconstruction of the temperatures experienced by the embryo, the nest microclimate, and time at which the parent left or returned to the nest, the latter indicated by temperature shifts of at least 1.5° C. The information contained in the data logger was downloaded every 10 days until the eggs hatched, or when the nest was no longer active due to predation or abandonment.

Provisioning Behavior and Nestling Growth.—The sensors were removed in the two nests where eggs hatched and the chicks were weighed daily to the nearest 0.05 g. Provisioning behavior was recorded by a motion sensor-triggered camera (PC85 Rapidfireprofessional; Reconyx Inc., Holmen, WI, USA) placed between 0.5 and 0.7 m from the nest entrance. We activated the camera to take 12 photographs with any movement between the nest entrance and the camera. Pectoral Sparrows are sexually dimorphic and it was possible to record differences in provisioning behavior by gender.

Data Analysis.—Incubation rhythm was analyzed following Londoño (2009). The algorithm used detected all intervals when temperature changed monotonically and three values were retrieved for each interval: duration, total decrease/increase in temperature, and initial rate of temperature increase/decrease. The start of an in-bout or off-bout period was triggered when temperature increased or decreased, respectively, at an initial rate of at least 0.5° C/min (Cooper and Mills 2005).

RESULTS

We found four nests in 2008 and 11 in 2009; most were found when one of the parents flushed. Incubation patterns were obtained in six nests for time spans that ranged from 1 to 15 days depending on how long the nest was active, for a total across all nests of 28 incubation days. Only two nests produced nestlings and were monitored for 2 and 9 days, respectively before all young were predated.

Nest and Eggs.—Nests had a bulky roofed cup with a side entrance and a spherical interior chamber. Fourteen nests were found $<$0.2 m above ground level on gentle slopes with poor drainage. Nest sites were usually within the vicinity of a stream, where the soil was saturated with water. The entrance of the nest faced down slope with the back of the nest against a live tree, a fallen log, or the slope. The only nest not found in these conditions was on a shallow shelf formed naturally in the bark of a live tree, ~1 m above ground level.

Average (± SD) external nest dimensions were 121.1 ± 27.3 × 132.8 ± 19.6 mm in length and width, and 124.8 ± 32.2 mm in height (n = 10). The nest entrance averaged 56.5 ± 25.8 mm in width × 75.7 ± 11.9 mm in height (n = 10). Internal distance from the entrance to the back wall of the chamber averaged 72.8 ± 14.0 mm (n = 10) with an average inner cup depth (where eggs were deposited) of 56.5 ± 25.8 mm (n = 10). We collected and weighed nests after they were no longer active; the average fresh nest mass was 48.0 ± 26.2 g (n = 5). All nests consisted of two layers, which were weighed separately. The outer layer was composed of dry bamboo (*Guadua* spp.) and dicotyledonous tree leaves, small roots, twigs, and fresh leaves of fern, and weighed 34.8 ± 25.3 g (n = 5). The proportion of materials used varied among nests with some having almost exclusively dry material (85%) in the outer layer while others had an equal proportion of dry and green materials (50%). The inner layer was mainly small pale brown rootlets (80%), and dry and fresh leaves (20%); it weighed 12.9 ± 3.2 g (n = 5).

The earliest nest was found on 28 August and the latest on 7 December, both with recently laid eggs; no developed embryo was visible when eggs were viewed against a bright flashlight. All nests had a clutch size of two. Egg color was highly variable among nests; four nests contained immaculate white eggs, while seven contained white eggs with brown speckles that ranged from sparsely to heavily speckled (Fig. 1). The eggs weighed an average (± SD) of 3.50 ± 0.33 g (range = 2.85–4.10 g, n = 23); and had an average length of 23.6 mm (range = 21.8–24.9 mm, n = 23) and a width of 17.4 mm (range = 16.1–17.9 mm, n = 23).

Provisioning Behavior and Nestling Growth.—Eggs in only two nests hatched due to predation and abandonment. The first hatched on 25 September and, although the chick was not measured until 28 September, it was possible to delineate hatching day by changes in incubation patterns recorded by the temperature sensors. The chick weighed 8.14 g on day 3 after hatching, had closed eyes, fine black down on the back, and small pin feathers covering the wings. The eyes were open on day 9 and the feathers had started to emerge, revealing an olive-gray color on the

FIG. 1. Eggs of the Pectoral Sparrow (*Arremon taciturnus*) in the foothills of Manu National Park, Cusco, Peru.

wings and flanks. The nestling gained on average 2.53 g per day between days 3 and 11. It weighed 28.4 g on day 11, the eyes were completely open, and the body and wing feathers opened further revealing olive and yellow coloration. Further measurements were not possible because the nest was empty on day 12, presumably due to predation. No tarsal measurements were taken for this nestling. Two chicks hatched from a second nest on 9 November. Their eyes were closed at hatch, the body was naked except for fine black down on the back, the interior of the mouth was bright red, and the beak was yellow. The young weighed 3.2 and 2.6 g and had a tarsus length of 5 and 6 mm, respectively. On day 1 they weighed 5.4 and 4.1 g and had tarsus lengths of 6 and 7 mm. They gained mass at a rate of 2.2 and 1.5 g per day, respectively. The nest was empty on day 2; the nest camera revealed an unidentified marsupial depredated the nest during the night.

The male provisioned the nestlings on 16 occasions over a 3-day period at the first nest, the female on five occasions and, in 10 cases, it was not possible to identify the gender of the parent. We recorded three events when the male fed the female while she was brooding the nestlings during day 4 after hatching. The food was too small and mashed for recognition in most cases; however, in three instances it was possible to observe what appeared to be insect parts. The male continued to provide most of the food to the nestlings (76%), even after the female stopped brooding. Removal of fecal sacs was solely by the male. It was not possible to ascertain whether or not the sacs were eaten.

None of the 15 nests was successful. Nine nests were depredated during the egg period, two during the nestling period, and four were abandoned for unknown reasons a few days after we started to monitor them. We made efforts to minimize nest disturbance, but observer interference cannot be ruled out as the reason for abandonment.

Incubation.—The longest incubation period recorded was 15 days. The laying date was unknown for this nest, but we believe the eggs were laid 1 or 2 days before being found since no embryo development was observed. Thus, the incubation period is likely between 15 and 17 days. The female was the sole incubator based on our observations, photographs, and videos.

The female had few but long absences each day (Fig. 2). On average the female conducted 7.4 trips per day (range = 4–10 trips, n = 18 days). Average trip length was 46.4 min (n = 18 days). The longest absence from the nest was 263 min, while the shortest was 6 min. On average, the female spent 57% (range = 20–65%, n = 18 days) of daylight incubating the eggs. The on-bout periods ranged from 8 to 323 min with an average of 71.7 min (n = 18 days). The female spent the night incubating in all nests, except for one instance, when the female spent the night outside the nest.

The female spent on average (± SD) 61 ± 3.7% of daylight incubating between days 4 and 10 in the nest that lasted 15 days with no trips longer than 60 min. In contrast, the female spent 55 ± 1.6% of daylight incubating between days 11 and 14 before hatching and 20% of trips were >60 min. Thus, females decreased on-nest time before egg hatching by 6 ± 1.3%, when 12% of the trips lasted >1 hr.

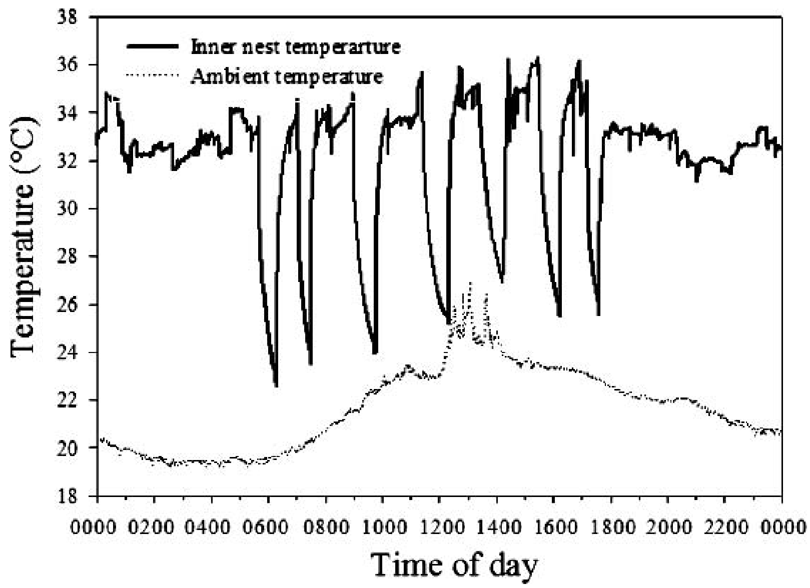

FIG. 2. Nest and ambient temperature patterns from a single nest of the Pectoral Sparrow during a 24-hr period.

The overall average (± SD) nest temperature was 27.9 ± 1.86° C (n = 28 days) and average nest temperature was 29.2 ± 2.64° C (n = 28 days) during incubation periods. Nest temperature decreased to an average of 26.6 ± 2.43° C (n = 28 days) during incubation recess. Overall average egg temperature was 32.0° C (range = 20.1–37.6, n =12 days); and 34.8° C (range = 27.7–36.0° C, n =12 days) when the female was on the nest; egg temperature decreased to 24.0° C (range = 18.4–36.1° C, n =12 days) during foraging trips.

DISCUSSION

Ours is the first study comparing behavioral differences within *Arremon.* It is of interest that nest architecture for two of the new species recently added to the genus, *A. brunneinucha* and *A. torquatus* (Cadena et al. 2007) differ greatly from other congeners. These two species nest in open cups in the foliage (Skutch 1954, Skutch and Stiles 1989), while the remaining species with known nests construct closed domes at ground level (Snethlage 1935, Skutch 1954, Haverschmidt 1968, Tye and Tye 1992, Auer et al. 2007).

All nests of Pectoral Sparrow were domed structures, similar to those described for other members of the genus (Skutch 1954, Haverschmidt 1968, Tye and Tye 1992, Auer et al. 2007). They were in predictable places (slopes next to creeks). Egg coloration was variable among females and incubation was solely by the female, which spent on average 61% of the daylight incubating and conducted on average 7.4 trips per day each lasting on average 46.4 min. The male supplied most of the food, although both parents provisioned the nestlings.

Nest and Eggs.—Dome nesting species within *Arremon* had similar nest locations and materials; average nest height for *A. flavirostris* and *A. taciturnus* was 0.0 m (range = 0.0–0.9 m, n = 54) and 0.1 m (range = 0.0–1.0 m, n = 15), respectively (Auer et al. 2007). In contrast, cup-nesting species, *A. brunneinucha* and *A. torquatus,* place their nests in vine tangles or bamboo between 1.2 and 8.3 m above ground with two nests recorded >20 m above ground (Skutch 1954, Skutch and Stiles 1989, Auer et al. 2007). Nest material also differed between cup- and dome-nesting species. Both have an external layer composed mostly of dead leaves and an inner lining of rootlets, but none of the cup-nesting species was reported to use green material, while all ground-nesting species have been reported to use green materials (moss, ferns, leaves or grasses) in the outer layer (Skutch 1954, Schulenberg and Gill 1987, Tye and Tye 1992). The use of green materials in nests of *A. aurantiirostris* and *A. castaneiceps*, as in *A. taciturnus*, appears to function to blend the nest with the surrounding vegetation (Skutch 1954, Schulenberg and Gill 1987).

Nest characteristics are a part of the extended phenotype that have been useful in reconstruction of avian relationships (Winkler and Sheldon 1993, Zyskowski and Prum 1999). Most of the species in the genus *Arremon* (Snethlage 1935, Skutch 1954, Haverschmidt 1968, Tye and Tye 1992, Auer et al. 2007) build dome nests on the ground. However, based on the latest phylogeny of the group (Cadena et al. 2007, Florez-Rodiguez et al. 2011), two additional species are now included in *Arremon* (*A. torquatus* and *A. brunneinucha*; previouly placed in the genus *Buarremon*). These species are not basal and build cup nests above ground (Skutch 1954, Skutch and Stiles 1989), suggesting the cup nest shape derived from the dome nest in the genus *Arremon*.

Egg coloration of *A. taciturnus* varied greatly between nests, ranging from immaculate pinkish glossy white to glossy white lightly or heavily spotted with brown speckles. Similarly, *A. castaneiceps* eggs were first reported to be white with heavy red spotting at the larger end (Sclater and Salvin 1879), and later described to be immaculate white (Schulenberg and Gill 1987). This difference was suspected to be due a mistaken label or species identification by Sclater and Salvin (Schulenberg and Gill 1987). The variability in *A. taciturnus* eggs could account for the differences reported in *A. castaneiceps* eggs, as both colorations were found in *A. taciturnus* eggs. Egg color variation may be common across the genus.

Incubation.—The incubation period of *A. taciturnus* appears to be similar to other *Arremon* members, based on the longest observed incubation period, which incubate between 15 and 17 days (Skutch 1954, Martin 2002). Nest attentiveness in *Arremon* is also remarkably similar among species. *A. taciturnus* had 57% nest attentiveness, *A. flavirostris* 62%, and *A. torquatus* 55% (Auer et al. 2007); all are below the average for neotropical passerines (69%; Martin et al. 2007). Average egg temperature for *A. taciturnus* was 32.0° C at an average ambient temperature of 24.4° C. The average egg temperature for other neotropical passerines species is 34.4° C at an average ambient temperature of 20° C (Martin et al. 2007). Despite being in a warmer climate, *A. taciturnus* eggs had a lower temperature. Ambient temperature could have, and does on many occasions, an effect on egg heat loss but the role the nest has on heat regulation is not well understood (Ar and Sidis 2002). Thus, inter- and intra-specific variation in egg heat loss cannot always be attributed to ambient temperature. Lower temperature of *A. taciturnus* eggs may be caused by long foraging trips by the female (on average 46.4 min), resulting in a 10.8° C difference between average egg temperature during off bouts (24.0° C) and on bouts (34.8° C). Birds may decrease the number of trips to the nest to reduce nest predation risk (Ghalambor and Martin 2002); the high predation risk in our study site may contribute to the low egg temperature and low nest attentiveness observed.

Average body mass of *A. taciturnus* of 26.7 g (Dick et al. 1984), in relation to egg (3.5 g) and clutch mass (7.2 g), was similar to the proportion observed in several neotropical passerines subject to high predation rates (Martin et al. 2006). This pattern may suggest reproductive investment is reduced by reducing clutch mass rather than egg mass with clutch mass being lower in species with high predation rates (Martin et al. 2006).

Nestling Growth, Provisioning, and Brooding.—The male supplied most of the food to the young once the eggs hatched. Most (76%) of the provisioning visits were by the male and only 24% by the female, based on 21 feeding visits where gender of the parent was known. A similar proportion was reported for *A. aurantiirostris* (male 75% and female 25%; Skutch 1954).

The breeding strategies of *A. taciturnus* include small clutch sizes with large eggs, female only incubation, low nest attentiveness, and the male as the main food provider; these are common strategies among neotropical passerines and are shared by all members of *Arremon* (Skutch 1954, Auer et al. 2007). The only aspect with nesting inconsistency among members of the genus was nest shape, placement, and material between the dome- and the cup-nesting species. These nesting differences are insufficient to support splitting of the genus. Analysis of behavioral differences among the traditional genera *Arremon, Buarremon,* and *Lysurus* paired with research on the genetics of the expanded *Arremon* genus may help resolve the phylogenetic relationships of the genus.

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