NESTING BEHAVIOR OF THE LILAC-CROWNED PARROT

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ABSTRACT.—Nesting behavior of the Lilac-crowned Parrot (*Amazona finschi*) was observed over a three year period at 24 nests in the tropical dry forest of the Chamela-Cuixmala Biosphere Reserve, western Mexico. Nest site characteristics and the pattern of parental care throughout the nesting cycle are described for this mainland Amazon parrot and compared with that reported for other Amazon parrot species. Nest sites were located in natural cavities of large mature trees characteristic of semi-deciduous forest. Nest sites were similar to one another in tree species, tree size, cavity height, and entrance width, indicating that Lilac-crowned Parrots may select nest sites based on these characteristics. Unlike most parrot species, Lilac-crowned Parrots showed low nest site reuse and high synchrony of nest initiation. Throughout the nesting cycle, females and nestlings were fed only twice a day on average. Nest attendance during feeding visits was short. The infrequent feeding visits and short nest attendance exhibited by Lilac-crowned Parrots corresponds with that found for other mainland Amazon parrots in northeastern Mexico, but contrasts with the multiple feedings and longer nest attendance observed for island Amazon species. The distinct aspects of Lilac-crowned Parrot nesting behavior may be related to predation rate and food resource availability during the extreme dry season. *Received 10 March 1999, accepted 15 July 1999.*

Most studies on the ecology of Neotropical Amazon parrots have been conducted on species inhabiting the Caribbean Islands (Snyder et al. 1987, Gnam 1991, Gnam and Rockwell 1991, Wilson et al. 1995). A comparative study of three species of mainland Amazon parrot in north-eastern Mexico found distinct differences compared with island species in some aspects of reproductive behavior and productivity (Enkerlin-Hoeflich 1995). Females and nestlings of three mainland Amazon parrot species were fed only twice a day (Enkerlin-Hoeflich 1995), in comparison with the multiple feedings observed for Caribbean Amazons (Snyder et al. 1987, Gnam 1991, Wilson et al. 1995) and other Neotropical parrots (Lanning 1991, Waltman and Beissinger 1992). Additional data on mainland Amazon parrots are needed to determine whether conclusions from studies on island species are applicable to mainland species. The Amazon parrot species of Mexico are particularly suited for comparison with the *Amazona* species of the Greater Antilles in the Caribbean because of their close evolutionary relationship (Snyder et al. 1987, Forshaw 1989). The Lilac-crowned Parrot (*Amazona finschi*) is en-

demic to western Mexico and has a restricted distribution from southeastern Sonora to Oaxaca (Forshaw 1989). There have been no studies on the ecology of the Lilac-crowned Parrot, and little is known of its breeding biology (Forshaw 1989). Anecdotal reports from captive breeding give an incubation period of 28 days, with the young chick leaving the nest after 60 days (Mann and Mann 1978). In this paper we present observations on the nest site requirements and nesting behavior of the Lilac-crowned Parrot in the wild, and compare them to observations for other island and mainland Amazon parrots.

STUDY AREA AND METHODS

Studies on the breeding biology of the Lilac-crowned Parrot were conducted at the 13,142 ha Chamela-Cuixmala Biosphere Reserve (19° 22′ N, 104° 56′ W to 19° 35′ N, 105° 03′ W) on the Pacific coast of Mexico. The study site has a dry tropical climate exhibiting a marked seasonality in precipitation, with 80% of the 748 mm average annual rainfall occurring June to November, and a prolonged drought from mid-February to late May (Bullock 1986). The reserve has a hilly topography varying in elevation from 20–520 m above sea level. The dominant vegetation type on the slopes is tropical dry deciduous forest, with semi-deciduous forest in the larger drainages and more humid valleys (Lott et al. 1987, Lott 1993). Monospecific forests of *Celaenodendron mexicanum* also occur as discontinuous patches within the tropical deciduous forest mosaic (Martijena and Bullock 1994).

Observations on the nesting behavior of Lilac-crowned Parrots were conducted from January to June in 1996–1998. Nest searches were carried out in Feb-

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TABLE 1.   Cavity dimensions for 26 Lilac-crowned Parrot nests.

Nest character	Mean	Standard deviation	Range	Coefficient of variation (s/m) × 100
Tree diameter at breast height (cm)	43.1	11.4	27.7–66.3	26.3%
Cavity height from ground (m)	9.7	1.7	7.4–14.7	17.8%
Entrance width (cm)	10.0	2.3	6.4–14.0	22.5%
Entrance length (cm)	21.0	16.0	7.5–71.6	76.2%
Internal diameter (cm)	19.9	6.8	10.5–35.0	34.3%
Cavity depth (cm)	66.2	51.7	24–260	78.1%
Circumference at entrance (cm)	86.7	30.0	26–135	34.5%
Nearest active nest (m)	948.9	707.7	25–2419	74.6%

ruary during the nest prospecting and early incubation phases of the parrot breeding cycle. No additional nests were located later in the nesting cycle because the behavior of breeding pairs made detection of nest sites difficult. A cavity was considered a potential nest site if one or both of the adult parrots were observed entering it. The cavity was considered an active nest site if one of the adult parrots remained within the cavity for longer than 30 min. Nest site reuse was determined from the frequency of cavity occupancy between years.

Access to nest cavities was achieved using both single-rope ascending (Perry 1978, Perry and Williams 1981) and a tree bole climbing technique (Donahue and Wood 1995). Nesting requirements of the Lilac-crowned Parrot were determined by measurement of nest cavity dimensions: tree species, diameter at breast height (DBH) of the tree, height above ground of the entrance, width and length of entrance, cavity depth, internal diameter, and circumference of the tree at entrance (Saunders 1979, Saunders et al. 1982). The location of each nest site and where possible the tree used by the nesting pair for the transfer of food from the male to the female were obtained using a geographic positioning system. The coefficient of variation was determined for the mean cavity dimensions to evaluate the variability of characteristics between nest sites.

Behavior of breeding pairs was determined by observations of parrot nests from covered blinds using 10 × 40 binoculars. Continuous dawn to dusk observations were conducted on 30 man-days (360 hours) at 8 nests. No activity was observed at nests during mid-day; therefore additional observations were restricted to the first four hours after sunrise and the last three hours prior to sunset giving an additional 299 hours of observation at 16 nests. Parental care and investment was evaluated from the number of feeding visits to the nest, arrival time, duration of feeding visit, time spent in the nest cavity, and time spent in the nest area (defined as within 100 m of the nest). Descriptive statistics are presented with means, ranges, and standard deviations.

RESULTS

Nest site characteristics.—A total of 29 nest sites were located in 1995–1998, all of which occurred in natural cavities. Nest cavities were located in live trees of *Celaenodendron mexicanum*, local name Guayabillo (51.7%, *n* = 15), and *Astronium graveolens*, local name Culebro (31.0%, *n* = 9). Of the remaining 5 cavities, 2 were located in a *Tabebua* species, 1 was located in a dead tree, and 2 were located in unidentified trees. Nest site reuse was low, with only 3 (10.3%) of the 29 nests sites located between 1995 and 1998 being used by nesting pairs over more than one breeding season. One cavity was used in three of the four years; 1995, 1997, and 1998. Two other cavities were reused once after a vacancy of one year.

Mean cavity dimensions for 26 active nest sites are presented in Table 1; three cavities could not be accessed for safety reasons. The cavity dimensions with the least variation were height of entrance from the ground and width of entrance. Diameter of tree at breast height was relatively consistent between nest sites and reflects the fact that parrot nests were located in large, mature trees characteristic of semi-deciduous forest. The greatest variability was found in depth of cavity and length of entrance.

Egg-laying and incubation.—Timing of egg-laying was highly synchronized between nests with most pairs commencing incubation within 14 days of the first nest being initiated. Mean nest initiation date was 6 February ± 4.6 (SD) days in 1996 (range: 30 January–13 February, *n* = 8), and 15 February ± 5.3

days in 1997 (range: 10–23 February, $n = 6$).

Nest attendance by the female was high during incubation, with the female leaving the nest only once in the morning and once in the afternoon to be fed by the male. The female spent a mean of 39.4 ± 26.5 min per day out of the nest over both morning and afternoon feeding sessions (range: 15–95 min per day, $n = 20$). Conversely, the male was rarely observed entering the nest or perching on the nest rim. Daily activity periods were consistent between nests with the male making an average 2.1 ± 0.3 nest visits per day (range 2–3 visits, $n = 35$) to feed the female. Mean arrival times for the morning and afternoon activity periods were respectively 08:24 EST ± 46 min (range: 06:07–10:08, $n = 45$) and 18:14 EST ± 26 min (range: 17:15–19:03, $n = 40$). Each feeding visit by a male lasted an average of 33.9 ± 25.6 min (range: 5–113 min, $n = 80$).

The male usually vocalized loudly on his approach to the nest area and perched in a tree adjacent to the nest cavity making low contact vocalizations until the female emerged. The nesting pair gave a characteristic take-off squawk, or bugle, as the female flew from the nest cavity to join the male. Food transfer from the male to the female took place in a regular perch tree located an average 423 ± 228 m (range: 149–983 m, $n = 11$) from the nest cavity. The food transfer session was the only time during the incubation phase when both adults were away from the nest area and was short in duration (average 11.5 ± 10.4 min, range: 2–48 min, $n = 78$).

Parental care.—Eggs hatched asynchronously, and females continued to brood nestlings during the day until the oldest nestling was 19.6 ± 2.7 days old (range: 15–23 days, $n = 9$). Females ceased roosting in nests overnight when the youngest chick was in its third week. During this early nestling phase, the male continued to feed the female twice a day and was occasionally observed to enter the nest for a mean 1.7 ± 2.8 min (range: 0–8 min, $n = 9$) per feeding visit. Later in the nesting cycle when the chicks were larger, both parents entered the nest to feed the young.

The behavior of nesting pairs altered once the female began to forage with the male.

Nesting pairs became more secretive around nests, arriving and departing silently. Pairs used low, almost inaudible vocalizations when in the nest area. Pairs were cautious about approaching the actual nest, and would not do so if they detected an observer or another disturbance. The nesting pair made an average 2.6 ± 0.9 visits per day (range: 2–4 visits, $n = 25$) to feed the nestlings. Average duration of feeding visits during the nestling phase was 72.3 ± 42.3 min (range: 12–171 min, $n = 31$). However, the nesting pair spent the majority of this time perched in trees around the nest area. Attendance at the actual nest cavity was short, lasting an average of 10.6 ± 11.2 min [range: 1.0–27.2 min, $n = 30$ (total time either adult in nest cavity or at entrance)], with a mean of 5.4 ± 4.5 min per visit (range: 0–17 min, $n = 30$) spent within the nest cavity, and a mean of 6.0 ± 12 min (range: 0–20.6 min, $n = 30$) perched at the nest rim. Each adult spent a mean of only 4.0 ± 3.5 min (range: 0.42–17 min, $n = 41$) inside the nest cavity per feeding visit. This was sufficient time to feed the young; however, there was no indication that parent birds spent any other time in the nest with the young except when feeding them.

Prior to fledging, nestlings began to climb to the nest entrance, and were fed at the nest rim. During this stage, nesting pairs spent more time perched near the nest entrance making low contact vocalizations to the young. Mean age at fledging was 63.7 ± 3.2 days (range: 56–68 days, $n = 22$). Nestlings fledged asynchronously, and all nests fledged young within a 2–3 week period. All nestlings fledged within 12 days in 1996 (mean fledge date = 10 May ± 4.34 days, range: 6–18 May, $n = 8$), 17 days in 1997 (mean fledge date = 18 May ± 6.68 days, range: 11–28 May, $n = 7$), and 13 days in 1998 (mean fledge date = 8 May ± 5.16 days, range: 2–15 May, $n = 7$).

DISCUSSION

The low variability between nest sites in tree species, size, cavity height, and entrance width suggests that Lilac-crowned Parrots may select nest sites based on these characteristics. Predation rates decrease with increasing height of nest sites from the ground (Nilsson 1984, Wilcove 1985), while the increased

size of nest entrance required by large birds may pose greater risks from predation, leading to specific requirements for entrance dimensions (Christman and Dhondt 1997). Amazon parrots in northeastern Mexico appear to select cavities based on tree species, cavity height, and entrance length (Enkerlin-Hoeflich 1995). Australian cockatoos also demonstrate species specific requirements related to body size for entrance dimensions and internal diameter of nest hollows (Saunders et al. 1982). Enkerlin-Hoeflich (1995) suggested that variability in several cavity characteristics combined with narrow criteria for a few key characters may provide parrots with the flexibility to exploit a wide range of available cavities while limiting predation and competition threats. In addition, low nest site reuse by Lilac-crowned Parrots is contrary to the 30–40% cavity reuse observed for most other parrot species (Saunders 1982, Snyder et al. 1987, Rowley and Chapman 1991, Smith 1991, Enkerlin-Hoeflich 1995). Natural predation is the main cause of nest failure for Lilac-crowned Parrots (Renton 1998), hence infrequent cavity reuse may help to prevent predators from learning nest site locations (Sonerud 1985, 1989).

The Lilac-crowned Parrot is notably different from other parrot species in its high synchrony in nest initiation, with all nests commencing within two weeks in each season, and the general nest initiation period comprising the first three weeks in February. There is no evidence that breeding pairs of the Lilac-crowned Parrot relay after a nest failure, which would also lengthen the nesting period. Most *Amazona* species have a 3–5 week nest initiation period each breeding season (Snyder et al. 1987, Gnam 1991, Enkerlin-Hoeflich 1995). The Monk Parakeet (*Myiopsitta monachus*) in Argentina extends egg-laying over a nine week period (Navarro et al. 1992). Australian cockatoos have a similar broad egg-laying period of 5–8 weeks (Saunders 1982, Smith and Saunders 1986, Rowley and Chapman 1991, Smith 1991). The nesting season of the Lilac-crowned Parrot may be so sharply defined by the extreme climatic seasonality in tropical deciduous forest and food resource availability. Nesting pairs may need to fledge young before the end of the long dry season in late May–June when food abundance de-

clines (Renton 1998). Delaying nest initiation may result in breeding pairs having to conduct energetically demanding activities of raising young during this environmentally difficult period.

The infrequent feeding visits to the nest by breeding pairs of the Lilac-crowned Parrot contrasts with the multiple daily feedings noted for island *Amazona* species (Snyder et al. 1987, Gnam 1991) and other Neotropical parrots (Lanning and Shiflett 1983; Lanning 1991; Waltman and Beissinger 1992; K.R., pers. obs.), but is consistent with the two nest visits per day observed for three mainland Amazon parrots in northeastern Mexico (Enkerlin-Hoeflich 1995). Morning and afternoon arrival times, approximately one hour after sunrise and one hour before sunset, for nesting pairs of the Lilac-crowned Parrot were similar to the three *Amazona* species in northeastern Mexico (Enkerlin-Hoeflich 1995). Large cockatoos in dry areas of Australia also restrict nest visitation activity to the early morning and late afternoon, spending the hot, midday periods resting under the shade of leafy trees (Saunders 1982). Lilac-crowned Parrots at the study site have been noted to demonstrate signs of heat stress during the mid-day hours of 12:00–14:00 by holding wings away from their bodies and panting with beaks open (K.R., pers. obs.). Therefore, restricting feeding activity to the early morning and late afternoon may enable parrots to conserve energy during high mid-day temperatures, particularly in dry habitats.

In addition to being infrequent, nest attendance by Lilac-crowned Parrots during feeding visits was brief. Most Lilac-crowned Parrot activity was conducted away from the nest area. Nesting pairs were never observed to forage near the nest, and food transfers from the male to the female took place an average 423 m from the nest. Island Amazon parrots, by comparison, may spend longer periods in the nest cavity brooding and preening young (Snyder et al. 1987), as well as conducting food transfers and foraging activities near the nest (Snyder et al. 1987, Gnam 1991). Infrequent visits, short nest attendance, and feeding away from the nest by Lilac-crowned Parrots may serve to limit the amount of activity in the nest area, and reduce the risk of attracting predators to the nest.

Breeding birds are restricted by competing demands to maintain their own energetic requirements and to protect and nourish the young (Martin 1987). While infrequent, short nest visits may reduce both mid-day energetic expenditures by foraging adults and the risks of nest predation, there is a cost in having to meet the energy demands of the young in a shorter time. Hence, variations in nesting behavior suggest that island and mainland Amazon parrots may be employing differing strategies to meet time constraints in caring for the young.

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