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SURVIVAL AND CAUSES OF MORTALITY IN JUVENILE PUERTO RICAN PARROTS

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Abstract.—Fifteen juvenile Puerto Rican Parrots (*Amazona vittata*) from wild nests in 1985, 1986 and 1987 were radio monitored an average of 110 ± 15.9 (SE) d (range 4–209 d) post-fledging. Minimum survival was 67% (n = 3) in 1985, 100% (n = 4) in 1986 and 43% (n = 7) in 1987. Most mortality (three of five deaths) occurred during the first 35 d following fledging. A major cause of mortality was predation by raptors. This research shows that additional studies are needed to define mortality causes to juvenile and adult free-flying Puerto Rican Parrots and to develop management guidelines to increase survival.

SUPERVIVENCIA Y FACTORES DE MORTALIDAD EN JUVENILES DE *AMAZONA VITTATA*

Sinopsis.—En estudio que se llevó a cabo de 1985 al 1987, quince juveniles silvestres de la cotorra de Puerto Rico (*Amazona vittata*) fueron monitoreados (luego de estos dejar el nido) con radiotransmisores por un promedio de 110 ± 15.9 días (alcance 4–209 d). La supervivencia mínima fue de 67% (n = 3) en 1985, 100% (n = 4) en 1986 y 43% (n = 7) en el 1987. La mayoría de las muertes (tres de cinco) ocurrieron durante los primeros 35 días, luego de que las aves dejaran el nido. La principal causa de mortalidad resultó ser la depredación por parte de rapaces. Este estudio indica que deben estudiarse un mayor número de individuos para determinar las causas de mortalidad de juveniles y adultos de la cotorra de Puerto Rico y desarrollar entonces guías para incrementar la supervivencia de la especie.

The endangered Puerto Rican Parrot, once abundant over the entire island of Puerto Rico and three satellite islands, is presently confined to the Luquillo Mountains where 2270 ha of virgin forest has been preserved (Wiley 1981). In 1937, Wadsworth (1949) estimated that about 2000 parrots existed in these mountains. The population continued to decline in subsequent years, however, until only 14 parrots remained in 1975. With intense management, the wild flock has increased at an average rate of 1.6 parrots per year from 1975 to 1987 (Lindsey et al. 1989).

Snyder et al. (1987) suggested that the failure of the wild flock to show a more substantial increase was due, in part, to high mortality of young and non-breeding parrots. From 1972 to 1979, Snyder et al. estimated

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annual mortality rates to be 32% for first-year birds and 15% for subadults and non-breeding adults. Between 1979 and 1985, the combined annual mortality rate for juveniles, subadults and non-breeding adults averaged about 29%. Annual mortality rates for breeding adults averaged 4% in 1972–1979 and 7% after 1979.

Causes of increased mortality of juvenile and non-breeding parrots were little known, although the Red-tailed Hawk (*Buteo jamaicensis*) was suspected to be a major source of mortality (Wiley 1981, Snyder et al. 1987). In 1985, we began a 3-yr radio telemetry study to determine movement patterns, survival and causes of mortality in juvenile Puerto Rican Parrots fledging from wild nests. This paper reports on survival and causes of mortality of juvenile parrots during the first 3–7 mo post-fledging. Home range and movements of these juvenile parrots were reported elsewhere (Lindsey et al. 1991).

STUDY AREA

This study was conducted in the Caribbean National Forest, a subtropical rain forest located within the Luquillo Mountains in northeastern Puerto Rico. The mountains encompass 19,648 ha and range in elevation from about 100 to 1075 m. The topography is extremely dissected with steep upper slopes. The mountains include five life zones (Ewel and Whitmore 1973) and are classified into four major vegetative associations, each roughly stratified by altitude: (1) tabonuco (*Dacryodes excelsa*) forest <600 m, (2) palm (*Prestoea montana*) forest on steep slopes and ravines >450 m, (3) colorado (*Cyrilla racemiflora*) forest >600 m and (4) dwarf (*Ocotea spathulata, Eugenia borinquensis*) forest on peaks and ridges >750 m. Annual rainfall varies from 300 cm in the foothills to more than 500 cm on the highest peaks. The annual average temperature is about 21 C (range = 11–32 C). A detailed description of the Luquillo Mountains can be found in Wadsworth (1949) and Odum and Pigeon (1970).

METHODS AND MATERIALS

Telemetry equipment.—We used low-drain, one-stage transmitters (Wildlife Materials, Inc., Carbondale, Illinois) weighing 5–7 g (2.0–2.3% of the parrot's body weight). (Reference to trade names does not imply endorsement by the U.S. Government). Transmitters had a 21-cm whip antenna, an effective radiated power of −33 to −37 dBm and an effective operating life of 4–7 mo. Transmitter signals were monitored with portable receivers (Wildlife Materials, Inc.; Telonics, Inc., Mesa, Arizona) and hand-held directional, 2- or 3-element antennas.

We attached transmitters to the parrots using a neck collar mount modified from a design recommended by E. Santana and S. A. Temple (pers. comm.). Santana and Temple found that other attachment methods (e.g., body harnesses, tail or body feather mounts, leg mounts) were not tolerated or the radios were destroyed by the parrots. The neck collar consisted of a 54 kg-test multistrand stainless steel fishing leader tied at the back of the parrot's neck with heavy gauge cotton thread. The cotton

TABLE 1. Monthly survival rates and sample size (in parenthesis) of radio-marked Puerto Rican Parrots in the Caribbean National Forest, Puerto Rico.

Months post-fledging	1985	1986	1987	Total
0–1	1.00 (3)	1.00 (4)	0.75 (6/8)[a]	0.87 (13/15)
1–2	0.67 (3)	1.00 (4)	1.00 (5)	0.92 (11/12)
2–3	1.00 (2)	1.00 (4)	1.00 (5)	1.00 (11)
3–4	—	1.00 (4)	0.75 (3/4)	0.87 (7/8)
4–5	—	1.00 (3)	1.00 (2)	1.00 (5)
5–6	—	1.00 (2)	0.00 (0/1)	0.67 (2/3)
6–7	—	1.00 (1)	—	1.00 (1)

[a] Transmitter signal from one parrot disappeared 28 d post-fledging. This parrot was included as a mortality to establish a lower limit to the survival estimate (see Kenward 1987).

thread, chosen because it eventually rots and breaks, allowed the parrots to lose the transmitter after the batteries died. The 2.5-cm inside diameter of the neck collar allowed the radio to hang loosely around the bird's neck to avoid interference with swallowing or neck movements.

Study procedures.—We radio-marked three nestling parrots from one family group in 1985, four nestling parrots from two family groups in 1986, and eight nestling parrots from three family groups in 1987. As only 2–4 parrot broods fledged per year (Snyder et al. 1987; Lindsey 1992), sample sizes were correspondingly small. We attached nonfunctional transmitters constructed of dental acrylic and a single strand 12-gauge copper wire collar to nestlings 2 wk before fledging to allow the adults and nestlings to adjust to the radios. About 1 wk before the birds fledged, we attached functional transmitters.

After radio-marked parrots fledged, we monitored them daily during daylight hours, 4–7 d per week until death or transmitter failure. Parrots were monitored an average 110 ± 15.9 (SE) d (n = 15, range 4–209 d). For surviving parrots, transmitter field life averaged 142 ± 13.1 (SE) d (n = 9, range 95–209 d). We determined the locations of individual parrots by triangulation from positions marked on trails within nest valleys and on peaks and ridges adjacent to parrot activity areas (Lindsey et al. 1991). When a parrot did not move during a 24-h period, we approached the last recorded location to confirm the status of the bird and recovered the carcass to determine the cause of death.

We calculated monthly survival rates using a ratio comparing the number of radio-marked parrots alive at the beginning and end of each 1-mo period (Kenward 1987). Mortality rates were equal to 1 minus the survival rate for each time period.

RESULTS

Minimum survival of radio-marked parrots was 67% (2/3) in 1985, 100% (4/4) in 1986 and 43% (3/7) in 1987 (Tables 1 and 2). In 1987, one parrot shed its transmitter 35 d after fledging and was deleted from

TABLE 2. Family groups, fledging dates, days monitored, and fate of radio-marked parrots, Caribbean National Forest, Puerto Rico, 1985–1987.

Family group Chick no.	Year	Fledge date[a]	Days	Fate
South Fork 1				
PH2	1985	29 June	35	Died; cause unknown
PR5-4	1985	to	95	Survived
PR5-5	1985	2 July	106	Survived
West Fork				
WF1B	1986	24 June	143	Survived
East Fork				
EF1B	1986	23 June	170	Survived
WF2B	1986	to	177	Survived
WF3B	1986	27 June	209	Survived
West Fork				
WF1	1987	24 May	4	Died; avian predation
WF2	1987	25 May	35	Parrot shed transmitter, fate unknown
South Fork 1				
PHA	1987	25 June	104	Died; cause unknown
PHB	1987	to 28 June	28	Signal disappeared; recorded as mortality
PHC	1987		101	Survived
South Fork 2				
SF2-1	1987	29 May	156	Survived
SF2-2	1987	to	163	Died; avian predation
SF2-3	1987	31 May	121	Survived

[a] Dates established when fledging occurred and does not reflect the order in which the chicks fledged.

the overall survival calculation. Monthly survival rates for the 3 yr combined varied from 0.67 during the sixth month to 1.00 during the third, fifth and seventh months (Table 1).

Mortality was highest during the first 35 d following fledging (Table 2). A major cause of mortality was avian predation as indicated by the plucked remains of two parrots. We found feather remains in tree branches and arboreal bromeliads 2.5–3.0 m above ground and scattered in an area measuring 5.0 m in diameter at the base of the trees. One intact transmitter was found wedged in a bromeliad 3.0 m above the ground along with some feathers and part of the parrot's skull and beak. The other intact transmitter was located at the base of the tree among the feather remains.

The two documented cases of avian predation occurred 4 d and 163 d after the parrots fledged (Table 2). The latter parrot (SF2-2), and its two nest mates, had joined the adult flock in July (7 wk after fledging) and were foraging and roosting with the flock. In late October, however, we located SF2-2 and one nest mate by themselves in a valley 2.5 km

from the main flock. Two days later, SF2-2's nest mate rejoined the adult flock leaving SF2-2 behind. SF2-2 remained alone within the valley, except for one afternoon when the adult flock returned there to forage, until 10 November when it was killed by an avian predator. We have no explanation as to why SF2-2 left the adult flock. For all other parrots monitored during the study, once they joined the adult flock, they remained with the flock.

We recovered the remains (feathers, bones and intact transmitters) of two other parrots under a root mass (one parrot) and within an area of 1 × 4-m on the ground (one parrot). Both carcasses had been scavenged, making it impossible to determine the cause of death. These parrots died 35 d and 104 d following fledging, respectively.

The radio signal for a fifth parrot disappeared 28 d after it fledged. This parrot was not recovered and was recorded as a mortality to establish the lower limit to the survival estimate (see Kenward 1987).

DISCUSSION

Low survival rates of juvenile Puerto Rican Parrots in the Luquillo Mountains continues to hamper rapid recovery of this species. From 1979 to 1988, 73 parrots (70 parrots fledging from wild nests and three juvenile parrots released from captivity) were added to the population. Yet the wild population increased by only 11 birds. The wild population was estimated at 25 parrots in March 1979 and 36 parrots in January 1988. These data, together with those showing 43–100% survival for radio-marked juvenile parrots, suggest that unidentified factors are continuing to affect survival of young parrots beyond the period reported herein (3–7 mo post-fledging).

Snyder et al. (1987) recorded an annual first-year survival of 68% for Puerto Rican Parrots based on estimates of the previous year's young that returned to the nest site with their parents at the start of the new breeding season. On 28 May 1987, we observed two of the four parrots radio-marked in June 1986 for a minimum annual survival rate of 50%. These two parrots were still carrying transmitters. Also, on 23 May 1988, one parrot radio-marked in 1987, and still carrying a radio transmitter, was observed in a flock of nine parrots. In each case the behavior and movements of these parrots were indistinguishable from non-radioed parrots.

Not all transmitters remained attached to the parrots long enough to allow an estimate of annual survival. One parrot radio-marked on 16 Jun. 1986 was observed (recognized by the band on its right leg) on 7 Nov. 1986 without its radio. On 29 Feb. 1988, a juvenile parrot without a transmitter was observed with its parents as they were inspecting their traditional nest site. The two nestlings from this nest site were both radio-tagged in May 1987.

In studies of other parrots, Rowley (1983) calculated, on the basis of band returns, a 43% survival rate for Galahs (*Cacatua roseicapilla*) during the first 4.5 mo post-fledging. He also reported that Wedge-tailed Eagles

(*Aquila audax*) were a major predator of this species. Saunders (1982) calculated an extremely low survival rate of 15% for first year White-tailed Black Cockatoos (*Calyptorhynchus funereus*). Saunders felt, however, that his survival figure was too low and suggested that the wing tags used to mark his birds placed them at a disadvantage compared with untagged individuals.

In our study avian predation was suspected to have been caused by Red-tailed Hawks. Except for an occasional wintering Peregrine Falcon (*Falco peregrinus*), the Red-tailed Hawk is the only large avian predator found in the Luquillo Mountains that is capable of taking free-flying Puerto Rican Parrots (Snyder et al. 1987, Wiley 1981). Red-tailed Hawks are able parrot predators and have been observed capturing Hispaniolan Parrots (*Amazona ventralis*) (Snyder et al. 1987), Bahama Parrots (*A. leucocephala bahamensis*) (R. Gnam, pers. comm.) and Black-billed Parrots (*A. agilis*) (Cruz and Gruber 1981).

Our research shows that additional studies are needed to define further mortality causes to juvenile and adult free-flying Puerto Rican Parrots and to develop management guidelines to increase survival.

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