Home Range and Movements of Juvenile Puerto Rican Parrots
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HOME RANGE AND MOVEMENTS OF JUVENILE PUERTO RICAN PARROTS

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Abstract: We studied home range and movements of 15 radio-marked, juvenile Puerto Rican parrots (*Amazona vittata*) fledging from wild nests during summer and fall, 1985–87. When juvenile parrots remained in the nest valley, home ranges during 1986 ($\bar{x}$ = 32 ± 10 [SE] ha, n = 4) were larger (P = 0.0079) than during 1987 ($\bar{x}$ = 13 ± 6 ha, n = 5). After radio-marked parrots integrated into adult flocks, home ranges during 1986 ($\bar{x}$ = 1,075 ± 135 ha, n = 3) were similar (P = 0.10) to 1987 ($\bar{x}$ = 416 ± 62 ha, n = 2). Juvenile parrots restricted their movements to nest valleys an average of 58 ± 29 days following fledging. After joining adult flocks, juvenile parrots routinely flew between the east and west slopes of the Luquillo Mountains but did not exhibit a seasonal pattern of movement. We recommend that captive-raised, juvenile parrots used in release programs be ≥5 months old to ensure they are mature enough to integrate into wild flocks.

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The historical range of the Puerto Rican parrot included the entire island of Puerto Rico and 3 satellite islands—Vieques, Culebra, and Mona (Snyder et al. 1987). As these islands were populated by Europeans and ensuing deforestation increased, the range of the parrot decreased. By 1940 the last remnant population survived in the Luquillo Mountains of northeastern Puerto Rico. Rodriguez-Vidal (1959) estimated that between 1953 and 1956 the Puerto Rican parrot's range was centered in an area of about 1,200 ha in the Luquillo Mountains. However, Snyder et al. (1987) believed the total range during this period was about 2,200 ha. The wild flock numbered 26 parrots in March 1990, making it one of the world's most endangered bird species.

During the early 1900's, parrots inhabiting the Luquillo Mountains were observed flying

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regularly from the mountains to the lowlands to forage (Snyder et al. 1987). These flights decreased in magnitude and distance with the passing years and, by the early 1970's, local residents stopped seeing parrots. Today, parrots restrict their activities to the forest and only occasionally leave the mountains.

During the early 1950's, when the population numbered about 200, the Puerto Rican parrot had a defined seasonal distribution (Rodriguez-Vidal 1959). Parrots occupied primarily the western portion of their range from August through October, the south central portion in November and December, the central portion in January and February, and were scattered over the entire area from March through July. During the 1970's, however, when the population consisted of 16–25 birds, parrots could be found almost anywhere within their range during any time of the year (Snyder et al. 1987).

Our objectives were to delineate the current home range and movements of radio-marked, juvenile Puerto Rican parrots in the Luquillo Mountains.

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STUDY AREA

Our study was conducted in the Caribbean National Forest, an 11,330-ha subtropical rain forest centrally located in the Luquillo Mountains in northeastern Puerto Rico. The Luquillo Mountains encompass 19,648 ha and range from 100 to 1,075 m in elevation. Topography is dissected with steep upper slopes. The mountains included 5 life zones (Ewel and Whitmore 1973) and were classified into 4 major vegetative associations (Wadsworth 1951, Brown et al. 1983) 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 (*Octea spathulata, Eugenia borinquensis*) forest on peaks and ridges >750 m. Annual rainfall varied from 300 cm in the foothills to >500 cm on the highest peaks. Average annual temperature was 21 C (range = 11–32 C). Detailed descriptions of the Luquillo Mountains were published by Wadsworth (1949) and Odum and Pigeon (1970).

METHODS

We radiomarked 3 juvenile parrots from 1 family unit in 1985, 4 from 2 family units in 1986, and 8 from 3 family units in 1987 (n = 15) (Table 1). We attached nonfunctional transmitters constructed of dental acrylic and a single-strand 12-gauge copper wire collar to nestlings 2 weeks before they fledged to allow adults and nestlings to adjust to the radios. About 1 week before the birds fledged, we attached functional transmitters. We used low-drain, 1-stage transmitters weighing 5–7 g (2.0–2.3% of the parrot's body mass), with an effective operating life of 4–7 months. We monitored transmitter signals with portable receivers and hand-held directional, 2- or 3-element antennas.

After radio-marked parrots fledged, we monitored them during daylight hours, 4–7 days per week until the transmitters stopped emitting signals. All parrots were monitored during each tracking period. During 1985 and 1987, we divided radiotracking into 4-hour periods: daylight–1000 hours, 1000–1400 hours, and 1400 hours–dark. We rotated tracking periods daily to uniformly monitor all daylight hours. During 1986, daily monitoring periods extended from daylight to dark.

During 1985, we estimated locations of individual parrots by walking into nest valleys and activity areas. Locations were plotted on 1:20,000 topographic maps using triangulation from 2 locations separated by >50 m. During 1986–87, we estimated locations of individual parrots by triangulation from permanent stations on trails within nest valleys and on peaks and ridges adjacent to parrot activity areas. Maximum distance from stations to parrot areas was 1.5 km, and 91% of the stations were <500 m. For each estimated location, we used 2 compass bearings with an intersecting angle >30° and <150° and a maximum time interval of 17 minutes between recording bearings. Average telemetry errors were −1.12° at 100–200 m based on 38 reference transmitters placed at 19 locations and 2.51° at 0.9–2.8 km based on 4 reference transmitters placed at 2 locations in the study area. Error polygons ranged from 0.5 to 2.0 ha at 100–200 m and from 12.2 to 118.4 ha at 0.9–2.8 km. We used the minimum convex polygon method (Mohr 1947) from the program TELEM (Coleman and Jones 1986) and the harmonic mean analysis (Dixon and Chapman 1980) incorporating 95% of the estimated use area to estimate home ranges for 1986–87. For the har-

Table 1. Fledging dates, radio-tracking histories, minimum convex polygon home ranges, and activity centers of radio-marked Puerto Rican parrots in the Luquillo Mountains, Puerto Rico, 1985–87.

Family unit and parrot	Fledging date[a]	Days monitored	No. locations	Days in nest valley	Home range (ha)		Activity centers (ha)
					In nest valley	After joining ad. flock	
South Fork							
PH2	29 Jun 85	35	[b]	[c]			
PR5-4	to	95	[b]	61			
PR5-5	2 Jul 85	106	[b]	61			
West Fork							
WF1B	24 Jun 86	143	122	25	21		
East Fork							
EF1B	23 Jun 86	170	542	23	34	1,205	37 473
WF2B	to	177	408	23	44	938	63 380
WF3B	27 Jun 86	209	564	23	28	1,083	30 521
West Fork							
WF1	24 May 87	4	4	[c]			
WF2	25 May 87	35	68	4[d]			
South Fork 1							
PHA	25 Jun 87	104	185	97	10		
PHB	to	28	51	[e]			
PHC	28 Jun 87	101	182	97	23		
South Fork 2							
SF2-1	29 May 87	156	180	75	13	432	5 1,172
SF2-2	to	163	252	75	9	520	234 386
SF2-3	31 May 87	121	185	75	12		

[a] Dates are when fledging occurred, not fledging order.
[b] Total number of locations was not recorded.
[c] Parrot died before leaving nest valley.
[d] Parrot lost transmitter 35 days after fledging.
[e] Radio signal disappeared before parrot left the nest valley.

monic mean analysis, we used 225 grid cells. Samuel et al. (1985) recommend using no more than 1 grid cell per data point. Sample size in our data varied from 180 to 564; therefore, we selected a grid density closer to the smaller sample. The method of collecting location data for radio-marked parrots in 1985 did not allow estimates of home ranges.

Because of logistical constraints, including the rugged terrain, no sampling plan with predetermined sampling times for each bird was possible. Also, individual birds could not always be located. Because of these difficulties, home-range estimates should be considered minimum use areas. However, data from parrots tracked for a sufficient time show relatively consistent movement patterns. To determine when we had an adequate sample to compute home-range sizes for individual radio-marked juveniles after they joined adult flocks, we calculated observation–area curves (Odum and Kuenzler 1955). We considered the curves to have reached an asymptote when inclusion of a weekly block of data resulted in <5% increase in area. We used the Wilcoxon 2-sample test to compare estimated home-range sizes between years.

We also calculated maximum straight-line distances between successive locations on the same day. Because there was not a uniform sampling interval between successive location estimates, these measures provide only a relative measure of the distances parrots moved during a day. Comparisons among years would not be warranted because sampling frequency differed among years.

RESULTS

We obtained 15 nestling parrots for radiomarking from 4 nests in 3 valleys 1.2–5.5 km apart. We estimated home ranges for 4 juveniles

in 1986 and 5 juveniles in 1987 while they remained in the nest valley (i.e., before the young parrots joined adult flocks) (Table 1). We estimated home ranges for 3 juveniles in 1986 and 2 juveniles in 1987 after they joined adult flocks. Increases in observation–area curves dropped below the 5% level by the 13th week of tracking for the 3 juveniles in 1986 and by the 16th and 19th weeks for the 2 juveniles in 1987. Remaining radio-marked juveniles were tracked for insufficient periods to reach an asymptote. We determined movement patterns for 2 juveniles in 1985, 4 juveniles in 1986, and 7 juveniles in 1987.

Home Range and Movements in the Nest Valley

Home Range.—Minimum convex polygon home ranges averaged 32 ± 10 ha ($n = 4$) during 1986, 13 ± 6 ha ($n = 5$) during 1987, and 22 ± 12 ha for both years combined. Home ranges were larger during 1986 than 1987 ($P = 0.0079$).

Movements.—Upon fledging, juveniles did not return to the nest cavity. While in the nest valley, the maximum distance radio-marked juveniles moved between consecutive locations during 1 monitoring period averaged 545 ± 78 m (range = 454–629 m, $n = 4$) during 1986 and 264 ± 92 m (range = 172–408 m, $n = 7$) during 1987.

Juveniles from individual family units remained in their respective nest valleys an average of 58 ± 29 days before leaving (Table 1). One exception occurred in 1987 when the West Fork family unit left the nest valley after a hawk killed 1 fledgling 4 days after the young parrots left the nest. The parents and surviving juvenile moved 1 km to a nearby valley. After fledging, radio-marked juveniles from each family unit remained together and did not join young parrots from other families, even when nesting only 420 m from another family unit.

Home Range and Movements After Joining Adult Flocks

Home Range.—Minimum convex polygon home ranges for individual juveniles averaged 1,075 ± 135 ha ($n = 3$) during 1986 and 476 ± 62 ha ($n = 2$) in 1987. Sizes of individual home ranges between years were similar ($P = 0.10$). Home range for juvenile parrots was 1,243 ha during 1986 and 822 ha during 1987. For both years combined, home range was 1,372 ha and measured about 6 km long and 2 km wide. Within this area parrots centered their activities primarily in 4 traditionally used valleys (East Fork, West Fork, South Fork, and Caimitillo valleys) of the Luquillo Mountains. Harmonic mean analysis indicated that each parrot exhibited a home range consisting of 2 activity centers (Table 1). The activity centers of each parrot were located in separate valleys, but activity centers of all parrots were located in the 4 traditionally used valleys.

Movements.—Juvenile parrots fully integrated into adult flocks 33–95 days ($\bar{x} = 56 \pm 23$) after fledging—about the time they first began traveling outside the nest valley. However, during 1987, 3 juveniles from the South Fork 2 family unit joined and foraged daily with an adult flock 45 days after fledging. This flock then remained in the nest valley another 28 days before moving 5.5 km to the eastern slope of the Luquillo Mountains.

After juveniles joined adult flocks, their home ranges and movements were the same as adults. The longest recorded flight for radio-marked juvenile parrots was 5.5 km during 1985. The maximum distance juvenile parrots moved between consecutive locations within 1 monitoring period averaged 2,058 ± 888 m (range = 844–2,955 m, $n = 4$) during 1986 and 991 ± 934 m (range = 294–2,349 m, $n = 4$) during 1987. Although juvenile and adult parrots routinely flew between the eastern and western slopes of the Luquillo Mountains, parrots remained scattered over the entire home range in separate flocks. Siblings remained together with their parents during periods of radiotracking.

DISCUSSION

Although forested areas in the Luquillo Mountains have substantially increased in the last 50 years, the range of the Puerto Rican parrot has not increased. If the range of the parrot was 2,200 ha during the mid-1950's (Snyder et al. 1987), parrots in our study used only 62% of this area. The smaller area used is probably a factor of (1) a smaller population of parrots (200+ in the mid-1950's to 34 in Jan 1989), (2) the discontinued use by parrots of the Icacos River valley (Snyder et al. 1987), (3) the limited duration (summer and fall seasons) of our study, and (4) an inability to locate parrots for short periods. We attribute the difference in home-range sizes while juveniles remained in nest valleys during 1986 and 1987 to parrots fledging from nests in valleys located on different slopes (east slope in 1986 and west slope in 1987) of the Luquillo Mountains.

Our study and observations by Snyder et al. (1987) indicate that after the wild population dropped from 200 to <34 birds, the Puerto Rican parrot no longer exhibited a seasonal distribution. During the past 20 years, parrots have remained in traditional roosting–nesting valleys the entire year and have made daily flights to foraging areas throughout their home range. The longest flight (5.5 km) we recorded is similar to flights of 7.0 km and a maximum flight time of about 10 minutes between extremes of the present range observed by Snyder et al. (1987). Puerto Rican parrot movements are apparently still oriented to take advantage of peak fruiting of locally abundant food sources (Rodriguez-Vidal 1959, Snyder et al. 1987).

MANAGEMENT IMPLICATIONS

Releasing captive-raised, juvenile parrots may increase the wild population of Puerto Rican parrots in the Luquillo Mountains and could be used to establish a second population in the Rio Abajo forest of western Puerto Rico (U.S. Fish Wildl. Serv. 1987). Rapid integration of free-flying, captive-raised parrots into the wild population is necessary to increase the parrots' protection from predators and to enable the parrots to identify and locate food sources. In addition, integration of juveniles into the wild flock before the onset of the breeding season when adult breeders disband may also increase their survival. Wild juveniles did not fully integrate into the wild flock until they were 3–5 months old and had been out of the nest 5–14 weeks. Therefore, we recommend that release programs use parrots ≥5 months old to ensure that captive-raised, juvenile parrots are mature enough to fully integrate into the wild flock.

Observations by Rodriguez-Vidal (1959) and Snyder et al. (1987) indicate that the Puerto Rican parrot is food-nomadic and relies on foods that are spatially separated and fruit asynchronously. To substantiate these observations, however, requires further study. To date, phenologies of important food species in the Luquillo Mountains are poorly known. Our study presents data only on range size and movement patterns of juvenile parrots during summer and fall. Data are needed on movement patterns and survival of juvenile and adult parrots throughout the year, and relationships between movements, peak fruiting seasons, and location and abundance of food sources.

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