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Roosting of Yellow-naped Parrots in Costa Rica: estimating the size and recruitment of threatened populations

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ABSTRACT. Many parrot populations are threatened with extinction due to habitat loss and collection for the pet trade. The loss of nest trees and chick poaching can drastically reduce reproductive success. However, due to the long life span of many parrots, populations are unlikely to become extinct rapidly even with complete reproductive failure. For parrots that travel in family groups, rapid estimates of reproductive success can be obtained by recording group sizes in areas where they congregate. We used roost counts over an 18-month period to estimate the size and productivity of a population of Yellow-naped Parrots (*Amazona auropalliata auropalliata*) in Costa Rica. Up to 300 birds were observed flying to roost on offshore islands near Curú National Wildlife Refuge. Roost counts were lowest during the breeding period (December–March), increased after fledging (April–July), and peaked during the late wet season (September–October). Increased food availability on the islands during the breeding season allowed the parrots to become seasonal island residents, and lowered roost counts during that period. We calculated reproductive parameters by assuming that groups of >2 birds were adults traveling with young. The percentage of young in the population was 12.5% and did not differ between years. Studies of group size in birds that form stable family groups, such as psittacines in the genera *Amazona* and *Ara*, are an inexpensive way to obtain estimates of the reproductive output of some parrot populations and determine if further study or intensive management are warranted.

SINOPSIS. **Individuos de *Amazona auropalliata auropalliata* pernoctando en Costa Rica: estimando del tamaño y el reclutamiento de una población amenazada**

Muchas poblaciones de cotorra estan amenazadas con desaparecer debido a la pérdida de habitat y a la colección de éstas para el mercado de mascotas. La pérdida de árboles para anidar y el robo de pichones pueden reducir drásticamente el éxito reproductivo. Sin embargo, dada la larga longevidad de las cotorras, la extinción rápida es poco probable, aún experimentando poco o ningún éxito reproductivo en un momento dado. Para cotorras que viajan en grupos familiares, se pueden obtener estimados rápidos del éxito reproductivo determinando el tamaño de los grupos en lugares en donde estas se congregan. A lo largo de 18 meses, utilizamos conteos en dormideros para estimar el tamaño y la productividad de una población de cotorras (*Amazona auropalliata auropalliata*) en Costa Rica. Unos 300 individuos fueron observados volar hacia un dormidero a una isla cerca del Refugio de Vida Silvestre Nacional en Curú. Los conteos más bajos en el dormidero fueron durante la época de reproducción (diciembre a marzo), incrementaron cuando volaron los pichones (abril-julio) y alcanzaron un pico durante la época de lluvias (septiembre-octubre). La disponibilidad de alimento incrementó en la isla durante el periodo reproductivo, permitiendo a las cotorras que se quedaran en la isla y se reprodujeran pero redujo el número de aves en el dormidero. Asumiendo que grupos mayores a dos, era la pareja de adultos con pichones, las aves jovenes representaron un 12.5% de la población total y este porcentaje no vario entre años. El conteo de aves en dormideros, de aves que forman grupos familiares estables (ej. psitacidos de los generos *Amazona* y *Ara*), puede ser una forma de bajo costo para obtener un estimado del impacto reproductivo y puede ayudar a determinar si se necesitan estudios adicionales o aplicar estrategias de manejo.

Key words: *Amazona auropalliata*, Costa Rica, island nesting, Psittacidae, roosting

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Of the nearly 140 species of parrots in the New World, about one-third are at risk of extinction (Bennett and Owens 1997, Collar 1997). Factors contributing to these declines include habitat loss, hunting, and capture for the pet trade (Collar 1997, Juniper and Parr 1998). Due to the long life span of many parrots, populations may persist for many years in areas where birds are experiencing little or no reproductive success (Brouwer et al. 2000, Wright et al. 2001, CITES 2002a, 2002b, Juniper 2002). This provides managers with the opportunity to address poaching and other demographic problems before these populations become nonviable, or extinct, and more drastic methods like reintroduction are needed (Snyder et al. 1996, Snyder et al. 2000). However, proper management requires information about population trends and reproductive rates, and such data are difficult and costly to collect via traditional nest-based studies. Rapid and accurate estimates of population sizes and trends and measures of reproductive success are needed if appropriate conservation measures are to be developed and initiated (Casagrande and Bessinger 1997, Snyder et al. 2000). This is of particular importance for parrots in the genus *Amazona*, with 19 species classified as either threatened or near-threatened with extinction (Collar 1997).

In areas where parrots roost communally, daily roost counts may permit targeted assessments of parrot populations. However, to date, only a few investigators have used roost counts to estimate populations of Neotropical parrots (Pitter and Christiansen 1995, Casagrande and Bessinger 1997, Harms and Eberhard 2003), and fewer have conducted counts for more than 12 months (Gnam and Burchsted 1991, Marineros and Vaughan 1995, Martuscelli 1995, Vaughan et al. 2005). Macaws and parrots in the genera *Ara* and *Amazona* apparently form stable family flocks (Snyder et al. 1987, Gilardi and Munn 1998), so flock size data for these species can be used to estimate recruitment rate, the proportion of breeders in a population, and the number of young fledged per brood. However, only three such studies have been conducted with macaws in the genus *Ara* (Munn 1992, Pitter and Christiansen 1995, Vaughan et al. 2005), and one with parrots in the genus *Amazona* (Martuscelli 1995).

Changes in flocking and roosting patterns during the postfledgling and nonbreeding seasons when food resources may be declining and more dispersed may provide parrots with increased opportunities to locate available food sources (Chapman et al. 1989, Renton 2001). Changes in food availability during the breeding season may also influence family group size when food is scarce because fewer parrots may survive to fledging age (Renton 2002). Nomadic and migratory movements of some parrots have been documented outside of the nesting season, presumably due to fluctuations in food availability and lack of breeding responsibilities (Powell et al. 1999, Renton 2001, Salinas-Melgoza 2003). Due to spatial and temporal changes in food availability throughout the year, many parrots must change their diets on a seasonal basis, leading to changes in habitat use, movement patterns, and roosting behavior (Chapman et al. 1989, Galetti 1993, Wermundsen 1997, Renton 2001).

Yellow-naped Parrots (*Amazona auropalliata auropalliata*) are large (550 g) Neotropical parrots (Stiles and Skutch 1989, South and Wright 2002) and are considered "vulnerable" throughout their range from southern Mexico to the northern Pacific slope of Costa Rica. In 2003, these parrots were listed in CITES Appendix I because of an apparent 50% reduction in population size over the last 20 to 30 years (Snyder et al. 2000, CITES 2002a, b). In Costa Rica, Yellow-naped Parrots roost in groups of 20 to 300 birds at roost sites that may be used for decades (Wright 1996). Because these parrots remain in family groups (pairs with offspring during the post-fledging and nonbreeding seasons) even when flying and roosting with other singles, pairs, and family groups, such groups are easily recognizable from each other (Stiles and Skutch 1989). Recruitment in this species appears to be limited by high levels of poaching, with 25% of nests poached in protected areas and 60% poached in nonprotected areas (Wright et al. 2001, CITES 2002b). In Costa Rica, Yellow-naped Parrots begin defending nests in December and early January, lay eggs in January and February, and fledge young from late March to late April. Brood sizes range from 1 to 4, and the mean number of fledglings per successful nest is 2.2 (South and Wright 2002, Rodriguez-Castillo 2004).

We used evening roost counts of Yellow-naped Parrots to estimate population size, the proportion of breeders, total number of young, number of young per family group, and percentage of young in the population. We also discuss the relationship between food availability in a coastal wildlife refuge and offshore islands with breeding, group size, and changes in overall roost count size. Yearly roosting cycles of these parrots, including their breeding, nonbreeding, and postfledging fluctuations are considered in relation to changes in food availability and changes in group sizes.

METHODS

Study area. Our study was conducted in the Curú National Wildlife Refuge (Curú) and the adjacent Tortugas Islands. Curú is a private refuge and farm located on the southern Nicoya Peninsula in western Costa Rica (09° 47′ N, 84° 56′ W). Rainfall totals approximately 2000 mm per yr, with a wet season from May–November and a dry season from December–April (months with less than 100 mm of precipitation; Vaughan et al. 1994). The mean annual temperature is 27.3° C (Vaughan et al. 1994). The site is located at the boundary of tropical dry forest, tropical moist forest, and tropical premontane forest life zones (Tosi 1969), and is a complex mosaic of mangrove forest, dry deciduous forest, semi-deciduous forest, mixed coconut forest, beach, pasture, gallery/evergreen forest along the Curú River, and plantations of teak (*Tectona grandis*) and mango (*Mangifera indica*; Zuñiga et al. 1993, Vaughan et al. 1994).

The Tortugas Islands include Alcatraz (0.8 km^2) and Tolinga (1.1 km^2) and are located 1.6 and 2.5 km east-southeast of Curú, respectively. The islands are covered by deciduous dry forest (Zuñiga et al. 1993). Based on observation of Yellow-naped Parrots nesting on the islands from January to March (several pairs documented nesting on each island during each year of the study), the islands appear to be an important nesting area for these parrots. Yellow-naped Parrots were not documented nesting on the mainland (in Curú or surrounding area) during our study (GDM, unpubl. data). The islands have no formal designation as a protected area and are currently managed by the local municipality. A tourism concession has been granted to a family on Tolinga Island.

Roost counts. We counted parrots as they flew from the mainland to roost on the Tortugas Islands. Counts were conducted from one point on a ridge at the northern end of Curú Bay (09° 47.548′ N, 084° 55.470′ W) about 50 m above the level of the bay. The point provided a clear, unobstructed view of the Tortugas Islands, Curú Bay, and the interior of the wildlife refuge to the west and south. Binoculars (10 × 50) and a 20 – 60x spotting scope were used during counts. All parrots passed through the area between the census point and the islands when returning to roost. As darkness approached, a 20 – 60x spotting scope was used to ensure that no parrots were missed. Prior to the study, we tested this technique from several locations and found we could accurately count the last few parrots going to roost before dark.

From February 2004 to July 2005, counts were conducted beginning 90 min before it was too dark for the parrots to return to the islands for the night. Counts began between 16:10 and 16:50, depending on the time of sunset. Preliminary data collected from October 2003–January 2004 (prior to this study) showed that all parrots returned to the islands to roost during the 90 min period before dark. In contrast, parrots left the islands over the first several hours of daylight in the morning, making morning counts more difficult and potentially less precise. Most parrots returned to roost 30 – 60 min before dark, with a few returning 5 – 30 min before dark. For this reason, we used only evening counts. During each count, we noted weather conditions (sunny, partly cloudy, cloudy, or drizzle). Counts were not conducted during heavy rain. Each time parrots were observed, we recorded the time, total flock size, and the number of singles, pairs, triplets, quadruplets, and quintuplets in each flock. Large flocks often contained many singles, pairs, triplets, quadruplets, and quintuplets, but each could be accurately identified due to the proximity of individuals in pairs and family groups and the time interval between successive flocks. Counts were randomly distributed during each month as suggested by Cougill and Marsden (2004).

We conducted 179 counts (269 h of observation) during our 18-month study. The number of counts per month ranged from five in August 2004 to 13 in February 2005. Adult Yellow-naped Parrots have a large yellow nape and could be easily distinguished from young and juveniles that have green napes, greenish blue crowns, and dark eyes (Stiles and Skutch 1989, Howell and Webb 1995, Wright 1996). Prior to our study, we documented foraging groups of Yellow-naped Parrots on the mainland in Curú and on the islands, and groups always included a single adult or juvenile, a pair of adults or juveniles, or two adults along with one to three additional fully-green parrots with dark eyes (juveniles). Most parrots in the genus *Amazona* remain in family groups even when roosting in larger aggregations (Martuscelli 1995, Gilardi and Munn 1998, Salinas-Melgoza 2003), including Yellow-naped Parrots in Costa Rica (Stiles and Skutch 1989). To estimate the proportion of breeders in the population and potential recruitment of young, we assumed that all groups of 3–5 parrots consisted of pairs with one, two, and three young, respectively (Munn 1992, Marineros and Vaughan 1995, Vaughan et al. 2005). We never documented family groups of >5 parrots (two adults and three juveniles). We estimated the percentage of young in the population by dividing the number of young by the daily total. Monthly means of percent young were calculated for counts with >40 birds to avoid overestimates. The number of young per family group was calculated for two years using data from June and July (2 to 4 months after fledging) when the estimated percent of young in the population was highest. Because family groups in other parrots in the genus *Amazona* break up about 5 months after fledging, the period from 2 – 5 months after nesting appears to be the best time to determine the size of family groups and the recruitment of recently-fledged young (Renton, pers. comm.).

Plant phenology data. Prior to initiating the study of plant phenology, we monitored the diet of Yellow-naped Parrots for approximately 10 months. Two methods were used to collect diet data: (1) walking transects from early-late morning (6:30–10:30) and early afternoon-sunset (14:00–18:00) in areas of known parrot activity, and (2) recording all opportunistic sightings of parrots foraging at any time of day. The number of foraging bouts was recorded for each plant species. A foraging bout was defined as a single parrot or group of parrots feeding. However, if a parrot or group of parrots flew to another tree of the same species or to another food source, an additional foraging bout was recorded (Galetti 1993, Wermundsen 1997, Renton 2001). To collect plant phenology data, we selected the 19 plant species that Yellow-naped Parrots were observed consuming at least twice (total diet included 34 plant species based on 121 foraging bouts). In Curú, we marked 5–12 individuals, as suggested by Frankie et al. (1974), of each of the 19 plant species ($N = 159$ trees combined). For each marked tree, all seeds and unripe fruits (the ripeness when parrots had been documented foraging on these species) were counted 1–2 times per month from March 2004–July 2005. For months when two counts were conducted, we present the results as an average of the counts for each month. For trees where the entire crown was not visible, the observed fraction was estimated and the number of fruits or seeds extrapolated to the whole crown (Chapman et al.1992, Soloranzo et al. 2000).

On the Tortugas Islands, we marked 5–6 individual trees of each of the six main food species found on the islands ($N = 31$ total trees). For each tree, all seeds and unripe fruits were counted once a month from December 2004–May 2005. For both Curú and the Tortugas Islands, we determined food availability based on the sum of all fruits counted on all trees (total food availability), the number of fruits per tree, and the percentage of tree species in fruit on a monthly basis.

Data analysis. We tested the effects of year, weather, and month on daily roost counts using 3-way ANOVA using a GLM procedure (Sokal and Rolf 1995). We used two-way ANOVA using GLM procedures to test the effects of year and month on the daily proportion of groups >2 (presumably pairs with young) and the proportion of birds presumed to be young of the year (second, third, and fourth birds in groups >2). Both proportions (% groups > 2 and % young) were normally distributed and arcsine transformation caused a greater deviation from normality, so the original proportions were used in the ANOVA analyses. Values are presented as mean ± 1 SD. For all statistical tests, $\alpha = 0.05$ was used.

RESULTS

Population counts. Parrots were observed going to roost on all but one evening (18 February 2004). Counts ranged from 0 to 300 birds ($\bar{x} = 84.3 \pm 56.6$, $N = 179$), with the maximum number observed on 17 September 2004. Weather (sunny, partly cloudy, cloudy, or light drizzle) did not affect the number of

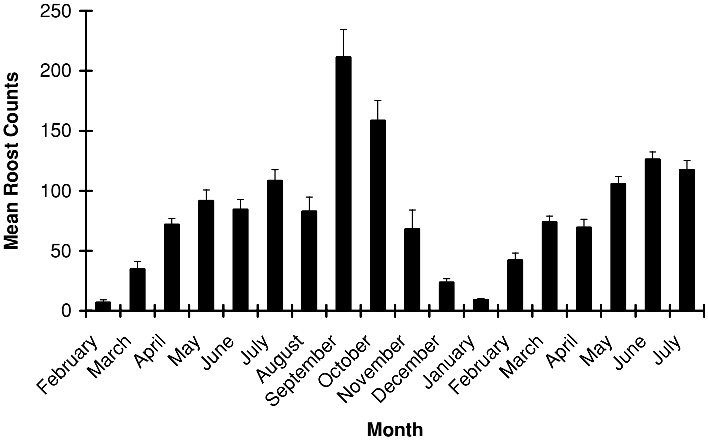

Fig. 1. Monthly mean (± 1 SE) roost counts (N = 179) of Yellow-naped Parrots from February 2004 to July 2005 in Curú National Wildlife Refuge and Tortugas Islands, Costa Rica.

birds observed flying to the roost ($F_{3,164} = 1.4$, $P = 0.23$). Roost use differed significantly among months, and was lowest from December–March and highest in September and October ($F_{11,164} = 36.5$, $P < 0.0001$; Fig. 1). Significantly more birds were observed from February – July 2005 ($\bar{x} = 88.5 \pm 37.1$ birds per count, N = 73 counts) than during the same period in 2004 ($\bar{x} = 70.2 \pm 39.7$ birds per count, N = 54 counts; $F_{1,121} = 17.8$, $P < 0.0001$). We only had data for both years for the period from February to July.

Group sizes and recruitment. The number of groups of three, four, and five increased during the postfledging period (May – September) in both 2004 and 2005 (Table. 1). For both years combined, the percentage of groups consisting of three, four, and five parrots was 23.3%, 4.9% and 2.2%, respectively. The number of young estimated in the population ranged from 0–29 per count ($\bar{x} = 5.56 \pm 6.49$, N = 179 counts), with annual maximums of 20 in October 2004 and 29 in June 2005. The maximum number of family groups increased from three in March and April to 12 in May and June and 14 in July.

The percentage of young in the population (estimated from group sizes) ranged from 0 to 25% and differed among months ($F_{11,158} = 22.6$, $P < 0.0001$), with peaks in June and July of both years (Fig. 2). The percentage of young in the population in June and July for both years was 12.5 ± 3.3% (N = 44 counts) and did not differ between years or between the months of June and July (2-way ANOVA: $F_{(years)1,41} = 1.72$, $P = 0.2$, $F_{(months)1,41} = 0.04$, $P = 0.85$). During June and July (both years combined), approximately 23 ± 5.6% of pairs (N = 44 counts) were observed with young, and this did not differ significantly ($F_{1,41} = 0.81$, $P = 0.37$) between years ($\bar{x} = 23.6 \pm 5.8\%$ in 2004, N = 20; mean = 22.1 ± 5.6%

Table 1. Distribution of group sizes among seasons for Yellow-naped Parrots in Curú National Wildlife Refuge, Costa Rica. Seasons are breeding (January-April), post-fledging (May-September), and non-breeding (October-December).

	Group size					N	Groups
	1	2	3	4	5	(counts)	per count
Breeding 2004	8%	86%	5%	1%	0%	26	21.5
Postfledging 2004	2%	81%	15%	1%	1%	41	53.9
Nonbreeding 2004	4%	83%	12%	1%	0%	28	45.1
Breeding 2005	14%	80%	5%	0%	0%	48	25.7
Postfledging 2005	9%	73%	12%	5%	1%	36	53.7

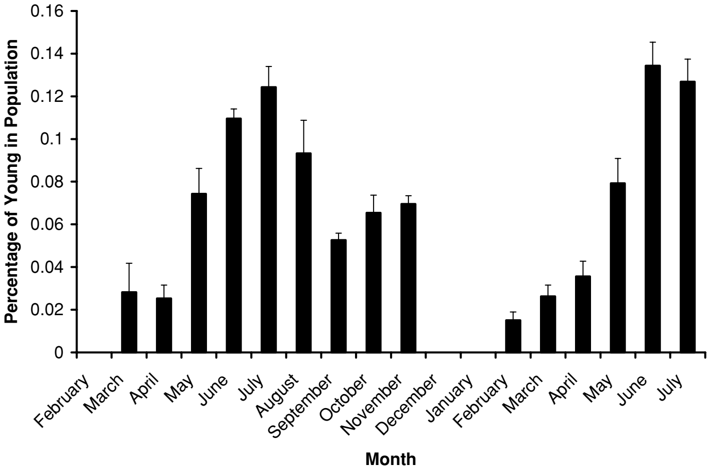

Fig. 2. Monthly mean percentage of young in a Yellow-naped Parrot population in Curú National Wildlife Refuge and the Tortugas Islands, Costa Rica, from February 2004 to July 2005. Percent young was calculated for counts with a minimum of 40 parrots ($N = 135$ roost counts).

in 2005, $N = 24$; Table 2). The estimated number of young per family group during June and July was significantly lower ($F_{1,41} = 21.1$, $P < 0.0001$) in 2004 ($\bar{x} = 1.16 \pm 0.13$) than in 2005 ($\bar{x} = 1.43 \pm 0.23$).

Food availability. Total food availability and the number of fruits per tree on the Tortugas Islands peaked in January and February, corresponding to the initiation of nesting (Fig. 3). We documented the initiation of nesting and incubation on both islands during these months. The islands contained primarily dry forest species that peak in food supply during the dry season. Food availability on the islands was estimated only for the dry/nesting season. It is unlikely that total food availability would be greater on the islands at any other time of year because the islands had few wet season fruiting trees, whereas Curú had a more diverse resource base of deciduous (dry season fruiting) and semi-deciduous (dry and wet season fruiting) habitat types. Curú also contained several coastal and plantation species that fruit and seed during the wet season. The number of fruits per tree in Curú peaked twice per year: February–March (mid-dry season) and July–August (mid-wet season, Fig. 3). Total food availability and the number of tree species in fruit in Curú followed a similar pattern. In September and October in Curú, only 21% (four of 19) of tagged tree species were in fruit, with the fewest number of fruits per tree in October.

DISCUSSION

Population estimate. We recorded a population of at least 300 Yellow-naped Parrots using the Tortugas Islands, making this among the largest communal roosts for the species in Costa Rica (Wright 1996). The use of islands

Table 2. Mean (± 1 SD) number of different group sizes of Yellow-naped Parrots in Curú National Wildlife Refuge, Costa Rica. Data are from the period approximately 2 – 4 months after fledging (June and July) during 2004 (N = 20) and 2005 (N = 24). Groups of three, four, and five parrots were assumed to be families with two adults and their young.

	Group size				
Year	1	2	3	4	5
2004	1.75 ± 1.29	32.2 ± 11.29	8.75 ± 3.02	0.55 ± 0.76	0.55 ± 0.83
2005	4.88 ± 2.49	39.46 ± 9.53	7.29 ± 2.63	2.88 ± 1.54	0.96 ± 0.91

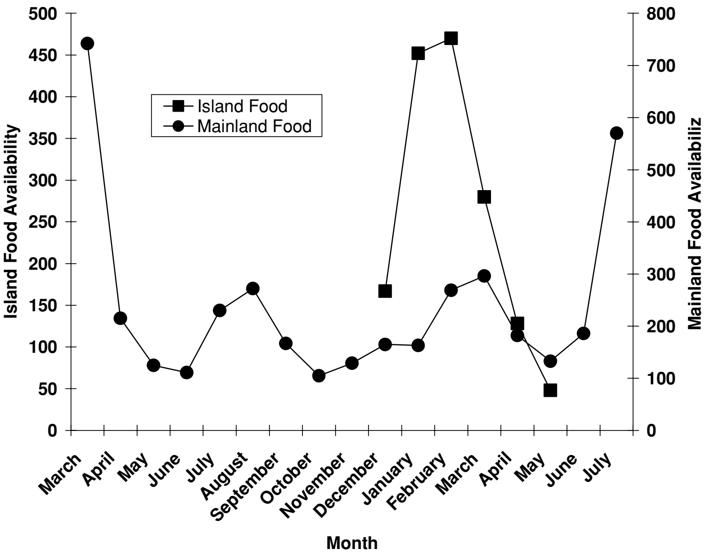

Fig. 3. Food availability in the Curú National Wildlife Refuge (March 2004-July 2005) and on the Tortugas Islands (December 2004-May 2005), Costa Rica. Food availability is presented as the total number of fruits and seeds for trees in Curú ($N = 159$) and the Tortugas Islands ($N = 31$).

for roosting and nesting has been documented in other species of parrots in the genus *Amazona* (Forshaw 1989, Sipinski et al. 2006, Berg and Angel 2006, DJB unpubl. data) and may be common among coastal populations of species in this genus. The number of individuals at roost sites of Yellow-naped Parrots ranges from 20–300, and there may be as few as 16 to 20 such roost sites in Costa Rica (Wright 1996, Wright and Wilkinson 2001). If true, the roost we studied represents a sizeable fraction of the total number of Yellow-naped Parrots in Costa Rica.

Roost counts appeared to be influenced by seasonal changes in population size resulting from an influx of parrots after fledging and from changes in food availability on the islands and in Curú. Roost counts of Yellow-naped Parrots were lowest during the breeding season (December–March). This may be due to the high availability of food on the Tortugas Islands at this time of year, making it possible for most parrots to meet their foraging and dietary needs on the islands without flying to the mainland. During this time of year, we counted >100 parrots flying between the two islands from one census location on Tolinga Island from sunrise to sunset (GDM, unpubl. data), suggesting that most parrots remain on the islands when food is available and they are not abandoning their roosting site during the nesting season. In contrast, other investigators have found that parrots abandon roost sites during breeding (Martuscelli 1995, Casagrande and Bessinger 1997, Cougill and Marsden 2004, Berg and Angel 2006). Therefore, food availability apparently affects seasonal variation in counts. Beginning in late March, island food supplies decline sharply, making it necessary for more parrots to fly to the mainland in the morning to forage and causing evening roost counts to increase when they return to the islands.

After breeding (April–June), there was an increase in the total number of parrots and the number of groups of three or more parrots, supporting our hypothesis that larger groups represent families traveling together. Similarly, young Lilac-crowned Parrots (*Amazona finschi*) and Great Green Macaws (*Ara ambiguus*) begin to fly with their parents 1 to 2 months after fledging (Powell et al. 1999, Salinas-Melgoza 2003, Salinas-Melgoza and Renton 2005).

The high counts we observed in September and October reflect the addition to the roost of many pairs without young. During these months, we recorded 2–3 times more pairs in the population than at any other time. This is about 5 months after the estimated fledging period for these parrots, and young Lilac-crowned Parrots in Mexico are also known to leave family groups about this time (Salinas-Melgoza 2003, Salinas-Melgoza and Renton 2005). As a result, the extra pairs observed at the roost may have been created by the break-up of family groups, with juveniles flying with other juveniles and adult pairs flying without attendant young. Presumably, during the nesting and post-fledging season, some of these parrots roost on the mainland or on other nearby islands in the Gulf of Nicoya.

The high number of pairs may also include nomadic pairs from other areas as maximum roost use (September and October) corresponds with the annual low in food supply (Figs. 1 and 3). Many parrot species wander and track food at the landscape level (Powell et al. 1999, Renton 2001, Salinas-Melgoza 2003). At this time, flocks of more than 50 Yellow-naped Parrots formed in the late afternoon in pastures and adjacent gallery/evergreen forest on the mainland to feed on *T. grandis* seeds, *Spondias mombin* fruits, and *Leucaena leucocephala* seeds. These trees are found in greater numbers in Curú than outside the refuge where there is extensive deforestation, and they are not present on the islands (GDM, unpubl. data). The influx of parrots during this time may be related to the presence of these food resources in the protected area of Curú at a time of low food availability on the islands and outside the refuge. Within 30 min of darkness, these flocks flew from the mainland to the islands to roost for the night. If these large flocks and the increased roost use during September and October were in response to reduced food supply on the islands, Curú, and in areas adjacent to Curú, then food supply may be most dispersed (lowest density of food) during this time of year. Parrots would likely need to spend more time searching for food when it is more dispersed, so an increase in roost size and foraging in larger groups could increase their ability to effectively track fewer food resources (Chapman et al. 1989, Renton 2001).

Reproductive output. Our estimates of reproductive output were based on family group size and the percentage of young in the population 2 to 4 months after fledging (June and July; Rodriguez-Castillo 2004; GDM, unpubl. data). Our estimate of 12.5% young in the population during 2004 and 2005 is within the range of estimates found in previous studies using family group size data for *Ara* and *Amazona* parrots. In lowland Peru, where nest sites were thought to be limiting, the percentage of young in a population of Red-and-green Macaws (*Ara chloropterus*) was 6.8% (Munn 1992). The percentage of young in a population of Scarlet Macaws (*Ara macao*) in a mixed agricultural/forested landscape of Costa Rica where nest poaching was known to occur was approximately 6.1% over several years (Vaughan et al. 2005). The percentage of young in a population of Red-fronted Macaws (*Ara rubrogenys*) in a mixed agricultural/forested area of Bolivia with abundant nest sites was 14% (Pitter and Christiansen 1995). The percentage of young in populations of Red-tailed Parrots (*Amazona brasiliensis*) ranged from 27.7–31.6% in a protected population to 2.3–4.6% in a non-protected area with heavy poaching (Martuscelli 1995).

Our estimate of 1.16 to 1.43 young per family group of Yellow-naped Parrots is lower than estimates from previous studies. Only two investigators have used family flock methods comparable to ours, with Martuscelli (1995) reporting 2.36 and 2.07 young per pair in two different years for Red-tailed Parrot roosts in Brazil and Munn (1992) reporting 1.4 young per pair for Red-and-green Macaws at a clay lick site in Peru. Estimates from nest-based studies are higher than those from flock size data, ranging from 1.48 for the Yellow-shouldered Amazon (*Amazona barbadensis*; Rojas-Suarez 1994) to 3.05 for the Hispaniolan Parrot (*Amazona ventralis*; Snyder et al. 1987). Nest-based studies use the number of chicks fledged per nest, whereas our data reflect mortality up to 3 months postfledging. Such post-fledging mortality in parrots may be considerable, with Powell et al. (1999) documenting 15% mortality of recently-fledged Great Green Macaws and 35% mortality of young during their first year. Munn (1992) estimated the number of young per pair at 1.5 in Peru, only 7% more than the estimate from the family group data in the same area. Additional studies are needed to determine the magnitude of the difference between these two methods of estimating reproductive output.

Little is known about the timing of juvenile independence in parrots. Lilac-crowned Parrots become independent when 5 months old (Salinas-Melgoza 2003), and Great Green Macaws become independent when 8–10 months old (Powell et al. 1999). Independence and dispersal of Lilac-crowned Parrots occurs when food availability begins to increase several months prior to the onset of the breeding season (Salinas-Melgoza 2003). In Curú, we found a similar pattern. The number of family groups begins to decline by the middle of November when food availability on the mainland begins to increase a few months before the onset of the breeding season. The almost complete lack of family groups by December suggests that most juvenile Yellow-naped Parrots are independent by 9–10 months of age.

Advantages of group size studies. Parrot populations suffering from complete reproductive failure should take many years to go extinct, due to the long-lived nature of these birds (Brouwer et al. 2000, Juniper 2002). Our study reveals how group size studies can provide estimates of reproductive output rapidly and inexpensively for parrots that travel in family groups. As a result, such studies can provide scientists and managers a way to quickly determine which populations have little or no reproductive output and help reverse these problems before more drastic measures are needed.

Another advantage of family group counts is that they include birds that fledge from all nests in the area, regardless of their characteristics. Family group data also accounts for the mortality of birds at fledging and, therefore, are more accurate than nest monitoring studies in measuring annual recruitment. Despite these advantages, family group data do have limitations. Studies like ours can only be conducted with species known to travel in family groups (genera *Amazona*, *Ara*, and *Andorhynchus*). Even for parrots in the genera *Ara* and *Amazona*, there has been no systematic study of how often apparent "family groups" consist of three or more adults or subadults (>1 year old) traveling together. Estimates of the percentage of young in the population would also be biased for species where young remain with parents for more than 12 months after fledging (Howell and Webb 1995). Another limitation is that group size studies do not help elucidate the causes of low reproductive success. As a result, intensive nest site studies are likely needed when group size data suggest reproductive failure.

Group size data are most efficiently collected at sites where parrots congregate (roosts, clay licks, and foraging areas), but can also be collected any time birds are seen (censuses, fixed point observations, or opportunistic encounters; Snyder et al. 2000). Group size studies should be included as an integral part of any comprehensive research plan on parrot species that travel in family groups and where these types of studies are feasible.

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