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SURVIVAL OF CAPTIVE-REARED HISPANIOLAN PARROTS RELEASED IN PARQUE NACIONAL DEL ESTE, DOMINICAN REPUBLIC

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Abstract. We report first-year survival rates of 49 captive-reared Hispaniolan Parrots (*Amazona ventralis*) released in Parque Nacional del Este, Dominican Republic. Our goal was to learn about factors affecting postrelease survival. Specifically, we tested if survival was related to movements and whether modifying prerelease protocols influenced survival rates. We also estimated survival in the aftermath of Hurricane Georges (22 September 1998). Twenty-four parrots, fitted with radio-transmitters, were released between 14 September and 12 December 1997. Twenty-five more were released between 29 June and 16 September 1998. First-year survival rates were 30% in 1997 and 29% in 1998. Survival probability was related to bird mobility. In contrast to birds released in 1997, none of the 25 parrots released in 1998 suffered early postrelease mortality (i.e., 3–5 days after release). Two adjustments to prerelease protocols (increased exercise and reduced blood sampling) made in 1998 may have contributed to differences in mobility and survival between years. The reduction of early postrelease mortality in 1998 was encouraging, as was the prospect for higher first-year survival (e.g., 30% to 65%). Only one death was attributed to the immediate impact of the hurricane. Loss of foraging resources was likely a major contributor to ensuing mortality. Birds increased their mobility, presumably in search of food. Survival rates dropped 23% in only eight weeks posthurricane. This study underscores the value of standardized prerelease protocols, and of estimating survival and testing for factors that might influence it. Inferences from such tests will provide the best basis to make adjustments to a release program.

Key words: Amazona ventralis*, Dominican Republic, Hispaniolan Parrot, movement, release program, survival, telemetry.*

Supervivencia de *Amazona ventralis* Criadas en Cautivero y Liberadas en el Parque Nacional del Este, República Dominicana

Resumen. Determinamos la supervivencia de 49 individuos de *Amazona ventralis* criados en cautiverio y liberados en el Parque Nacional del Este, República Dominicana. El proyecto se diseñó para aprender sobre los factores que pueden influenciar la supervivencia de las cotorras dominicanas. Específicamente, pusimos a prueba si la supervivencia estaba relacionada a movimientos y si modificaciones al protocolo de pre-liberación influenciaron la supervivencia. También estimamos la supervivencia de las cotorras después del paso del huracán Georges el 22 de septiembre 1998. En 1997 se liberaron 24 cotorras con radio transmisores entre el 14 de septiembre y el 12 de diciembre. Otras 25 se liberaron entre el 29 de junio y el 16 de septiembre de 1998. La estimación de la supervivencia en 1997 fue de un 30% y en 1998 de un 29%. La probabilidad de supervivencia estuvo relacionada a la movilidad del ave. En comparación con las cotorras liberadas en 1997, ninguna de las cotorras liberadas en 1998 murió durante los primeros 3–5 dias post-liberación. Dos ajustes a los protocolos de pre-liberación en 1998 contribuyeron probablamente a las diferencias en movilidad y supervivencia entre años. Este resultado fue alentador, así como el prospecto de alcanzar tasas más altas de supervivencia (e.g., 30% a 65%). La muerte de sólo una cotorra se atribuye al impacto directo del huracán. La pérdida de recursos alimenticios

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probablemente contribuyó fuertemente a la mortandad subsiguiente. Las cotorras exhibieron mayor movilidad, presumiblemente en búsqueda de frutos. La tasa de supervivencia disminuyó un 23% en solo ocho semanas después del huracán. Este estudio enfatiza el valor de protocolos de preliberación estandarizados y de estimaciones de tasas de supervivencia que ponen a prueba factores que la puedan influenciar. Las inferencias de dichas pruebas proveerán un mejor fundamento para ajustar los programas de liberación.

INTRODUCTION

Release programs are not uncommonly used to augment wild populations of parrots or reintroduce a species to parts of its former range (Lambert et al. 1992, Wiley et al. 1992). Implementing release programs can be expensive and logistically complex, but could also play an integral role in the recovery of endangered psittacines such as the Puerto Rican Parrot (*Amazona vittata*; USFWS 1999). Yet, the diversity of circumstances often complicates extrapolation of results to other species. These circumstances include nonstandardized prerelease protocols, use of confiscated versus captive-reared birds (Snyder et al. 1994), and use of wild-hatched but captive-reared birds (Sanz and Grajal 1998).

Another limitation precluding easy extrapolation of results is that most release programs fall short in their attempts to relate the metric of interest, survival, to factors that might affect it. Two examples relevant to the recovery of the Puerto Rican Parrot illustrate this point. In 1982, two groups of 18 Hispaniolan Parrots (*Amazona ventralis*) were released in the Dominican Republic (Snyder et al. 1987). The study was designed to evaluate the relationship between the degree of prerelease training given to birds and their postrelease survival. One group (the ‘‘soft release’’) was exposed to locally occurring fruits and seeds for 9–12 days prerelease and provided with food, water, and shelter postrelease. The second group (the ‘‘hard release’’) was not trained or supplemented with food. There were no survivors from the hard release. In contrast, five of nine birds of the ‘‘soft release’’ survived two months, after which monitoring efforts stopped. In 1985, three Puerto Rican Parrots were released in the Luquillo Mountains under a hard release protocol. One individual was seen alive about six months after release and an individual was later reported breeding, in 1989 (Meyers et al. 1996). The full benefits of these release experiments were not reaped because they were not replicated, monitoring efforts were brief, and monitoring was not designed to clarify the relationship between prerelease protocols and early postrelease survival.

In this work, we report first-year survival rate of 49 captive-reared Hispaniolan Parrots released in Parque Nacional del Este, Dominican Republic, in 1997 and 1998. Our goal was to understand factors affecting survival rates, particularly those related to prerelease protocols. To facilitate inferences to other psittacines from our work, preparation and training of captive-reared Hispaniolan Parrots was extensive and standardized (Joyner et al. 1997, Collazo et al. 2000). This included selecting socially compatible birds for release groups, standardizing exercise regimes, and allowing minimal contact with humans.

We hypothesized that parrots exhibiting higher mobility in the wild were more likely to survive. Potential benefits from greater postrelease movement include increased foraging ability and minimized predation (Beck et al. 1994). To test this hypothesis we calculated an index of movement and examined its functional relationship to survival. We also compared differences in flight muscles (as a measure of physical condition) after adjusting prerelease protocols based on lessons learned in 1997. We also calculated hypothetical survival rates modeled on different values of early postrelease mortality.

On 22 September 1998, Hurricane Georges made landfall on the park with sustained winds of 224 km per hr. We took advantage of this ‘‘natural experiment’’ to estimate posthurricane survival rates of 25 birds released in 1998. To our knowledge, this was the first attempt to quantify survival rates of an avian species in the aftermath of a hurricane in the Caribbean (Wiley and Wunderle 1992). We documented mortality rates due to the immediate impact of the hurricane and those due to habitat degradation (Wiley and Wunderle 1992). To evaluate the latter, we tested for differences in movements before and after the hurricane under the prediction that movements would increase as birds searched for food in a degraded landscape. In support of our working hypothesis, we also compared estimates

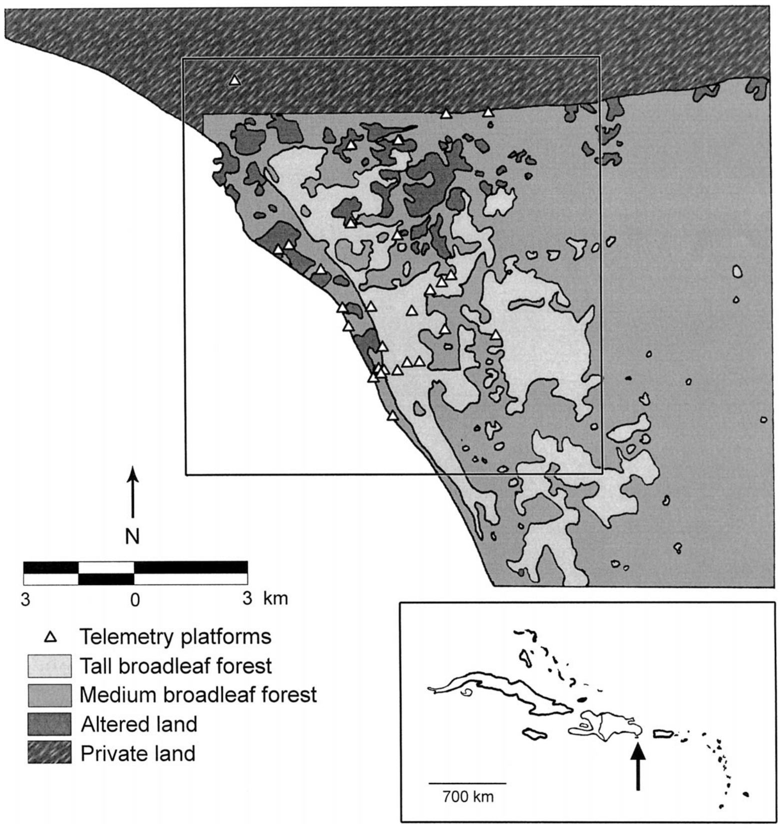

FIGURE 1. Map of the Dominican Republic showing location of Parque Nacional del Este. In 1997 and 1998, we released Hispaniolan Parrots in the northeast of Parque Nacional del Este, Dominican Republic. The map indicates land cover types and location of telemetry stations. "Altered land" includes agriculture, pasture, and settlements. The inset shows the location of the park on Hispaniola.

of fruit abundance of nine plants used by parrots before and after the hurricane.

METHODS

STUDY AREA

The study was conducted in the Parque Nacional del Este (18°20′N, 68°45′W), Province of La Altagracia, southeastern Dominican Republic (Fig. 1). The park encompasses 42 000 ha of primarily subtropical dry and subtropical moist forests (Holdridge 1967). Elevations range from sea level to approximately 70 m, with generally moderate topographic relief. Principal overstory tree species include cupey (*Clusia rosea*), gregre (*Bucida buceras*), gumbo-limbo (*Bursera simaruba*), lechecillo (*Sideroxylon foetidissimum*), doveplum (*Coccoloba diversifolia*), and holywood lignumvitae (*Guaiacum sanctum*). Detailed descriptions of the geology, flora, fauna, and land use in the park were provided by Abreu and Guerrero (1995). We chose the northwestern quadrant of the park as the release area (ca. 5000 ha). Difficult access and few personnel made it impossible to establish other release sites. A network of trails and canopy-level observation platforms was constructed to track birds (Fig. 1).

RELEASES

We used young birds (<2 years) because they learn rapidly (Joyner et al. 1997). Birds were kept in a T-shaped flight cage in Puerto Rico for 5 months to select compatible release groups (i.e., nonaggressive interactions). In the Dominican Republic, parrots were placed in training cages built in areas frequented by resident parrots. Each cage held four parrots and measured 3.6 m long × 1.5 m wide × 2.1 m tall. Birds were fed a combination of commercial parrot feed and locally occurring foods. We placed unique dummy collars weighing 11 g (weight of actual transmitters) on parrots to acclimate them to transmitters. Releases occurred as soon as possible following the mandatory 40-day quarantine required by Dominican law. Three to five days prior to release each bird was given a veterinary examination and fitted with a transmitter.

Parrots were released in a staggered fashion as they became available after clearing prerelease protocols and CITES and Dominican Republic health and permitting processes. In 1997, we released four groups: two groups of four (14 September and 3 October) and two groups of eight (13 October and 8 December). In 1998, we released three groups: two groups of eight (29 June and 3 September) and a group of nine (16 September). We used a minimum group size of four to confer advantages of social interaction, predator avoidance, etc. Releases were scheduled to coincide with periods of high food availability and formation of mixed-family flocks (Snyder et al. 1987).

In 1998, we made two modifications to 1997 prerelease protocols. The first one entailed subjecting birds to a more rigorous exercise regime. Two persons made birds fly repeatedly along the long axis of the cage using aviary capture nets. A third person recorded number of laps flown and monitored stress level of birds. In 1997, birds were exercised twice weekly beginning two weeks into their quarantine period. In 1998, birds were exercised beginning on the third day of quarantine, and then three or four times weekly until a week prior to release, when they were exercised every day. The second modification consisted of reducing the quantity of blood collected for medical tests and the number of parrots sampled 2–5 days prior to release. In 1997, 2 mL per bird was collected. In 1998, only half the parrots (randomly chosen) were sampled and only 1 mL was collected.

We used Holohil (Carp, Ontario, Canada) SI-2C transmitters with unique frequencies between 164 and 165 MHz (Meyer et al. 1996). Birds were tracked five to six times per week using a Telonics (Mesa, Arizona) TR-2/TS-1 receiver/scanner. Bearings to transmitters were determined using the loudest signal method (Springer 1979) and acquired using a Suunto handheld compass corrected for declination. Angular telemetry error was $\pm 2.4°$(Collazo et al. 2000).

STATISTICAL ANALYSES

We used a modified Kaplan-Meier procedure to estimate survival, which allows for the staggered entry of individuals (Pollock, Winterstein, et al. 1989). We assumed that survival differences between birds of age 0–1 and 1–2 were negligible. The survival function is the probability of an arbitrary animal in a population surviving *t* units of time (in our case weeks) from the beginning of the study (Pollock, Winterstein, et al. 1989, Pollock, Winterstein, and Conroy 1989). We also report the hazard function, or one minus weekly survival, necessary to assess sources and extent of biases of point estimates (Tsai et al. 1999). We met all model assumptions except the one stipulating survival times are independent for different animals. Trying to adjust for lack of independence would have denied the fact that the species is gregarious. Violating this assumption meant that precision levels around our survival estimates were narrower than expected, although it is not known by how much (K. H. Pollock, North Carolina State University, pers. comm.). Criteria to determine when birds were ‘‘censored’’ (i.e., transmitter signal not detected but parrot not confirmed dead or alive in a given sampling occasion) were stringent to minimize biases (Tsai et al. 1999). Censoring in this study was due either to transmitter failure or to parrots that emigrated from the study area. If tracking suggested that the birds had not moved in one or two days, a concerted effort was made to locate the individual to ascertain whether it was dead or alive.

For birds released in 1997, we used 53 weeks from time of the first release (14 September) as the cutoff point to estimate first-year survival. We also applied the Kaplan-Meier procedure to 1998 data, but only for 16 weeks. On 22 September 1998, Parque Nacional del Este sustained a direct hit by Hurricane Georges. Treatment of post-hurricane data differed from 1997 in that instead of using weeks we used semimonthly intervals to match helicopter flights used to track birds. The unusually high censoring of individuals after the sixteenth week posthurricane, however, precluded estimating first-year survival using Kaplan-Meier (Miller 1983, Pollock, Winterstein, and Conroy 1989, Tsai et al. 1999). The 1998 survival estimate was instead obtained using the Mayfield method (Johnson 1979). To gain further insights on inter-annual survival patterns, we also calculated the

1997 survival estimate using the Mayfield method. We used the Kaplan-Meier estimator to calculate a hypothetical survival scenario, one exploring the potential survival rate if early postrelease mortality was eliminated. This value would have been estimable for birds released in 1998 had it not been for Hurricane Georges. To obtain the hypothetical survival estimate we simply removed early postrelease mortality from 1997 data. Mortality after the first week postrelease was left unchanged.

To assess the relationship between movements and survival, we calculated an index of movement. We calculated the index as the sum of sequential one-way movements of individuals from the release sites within our study area (White and Garrott 1990). The index is expressed in kilometers. We used this metric because sampling intensity among birds was unequal and successive observations were serially correlated (Swihart and Slade 1985). This index was computed as the mean squared distance from each location to the geometric center of activity for that individual. This index varies inversely with degree of contagion of locations. Moreover, because this index is a function of both home-range size and internal distribution of locations within the home range, it allows comparisons of movement and space-use patterns between individuals or groups. Computations were performed using the Advanced Statistics option within the ArcView 3.1 Movement Module (ESRI 1996).

We used logistic regression to determine the relationship between the likelihood of survival and movement index. Birds included in the analyses had comparable sampling periods. One analysis examined the relationship for birds (alive or dead) during 1997 and 1998 (prior to Hurricane Georges). A second analysis examined the relationship only for birds monitored after Hurricane Georges. We used *t*-tests to compare (1) movement between parrots that survived and died in 1997, and (2) movement by parrots released in 1998 (prior to Hurricane Georges) to parrots that survived or died in 1997. We used a one-tailed paired test to determine if movement patterns of birds monitored after Hurricane Georges were greater than before. Data were log transformed to meet the homogeneity of variances assumption (Levene's test, $P > 0.05$).

We used keel scores (1–4) as an index of flight muscle condition (Joyner et al. 1997). Scores were determined by trained observers, who palpated the center keel with the index and middle fingers. Muscle condition was scored as follows: 1 = emaciated with very sharp angle of muscle falling away from the center keel, 2 = moderately thin with sharp angle of muscle falling away from the center keel, 3 = normal to slightly thin with only a slight angle of muscle falling away from the center keel, and 4 = overweight with the muscle/fat rising above the center keel. Differences in keel scores were examined using a median test.

To evaluate differences in food abundance before and after Hurricane Georges, we established two phenology transects (1.4 km long) that ran throughout most of the study area, in which we marked 10 individuals of each of nine plant species (*Acacia macracantha*, *Bucida buceras*, *Bursera simaruba*, *Clusia rosea*, *Coccoloba diversifolia*, *Guaiacum sanctum*, *Pithecellobium arboreum*, *Sideroxylon foetidissimum*, and *Spondias mombin*). Plant species were selected based on Hispaniolan Parrot foraging observations made in 6–8 months prior to releases, and following initial 1997 releases (Collazo et al. 2000). Weekly, we recorded the number of flowers and fruits on each marked plant. Data were placed in one of nine categories used to estimate each individual's monthly ripe and unripe fruit abundance (0 = none, 1 = 1–10, 2 = 11–50, 3 = 51–100, 4 = 101–500, 5 = 501–1000, 6 = 1001–5000, 7 = 5001–10 000, 8 > 10 000). We used the ripe fruit average of the abundance categories' midpoints as our estimator (index) of fruit abundance for each species (Carlo et al. 2003). Our estimate of total fruit abundance per month was the sum of the averages of all plant species. We tested for differences in total fruit abundance by considering abundance values four months before and after the hurricane using a Wilcoxon signed-rank test. We used the values from 21 September and 7 October 1998 (i.e., immediately before and after the hurricane), and paired January, February, and March of 1997 and 1998 to avoid introducing seasonal effects into the comparison. We conducted all statistical analyses with JMP (SAS Institute 1994). We report means ± SE. Kaplan-Meier and Mayfield estimates are reported with their lower and upper 95% confidence intervals. We used a *P*-value of 0.05 to determine test significance.

RESULTS

The Kaplan-Meier first-year survival estimate for birds released in 1997 was 30% (CI: 10–

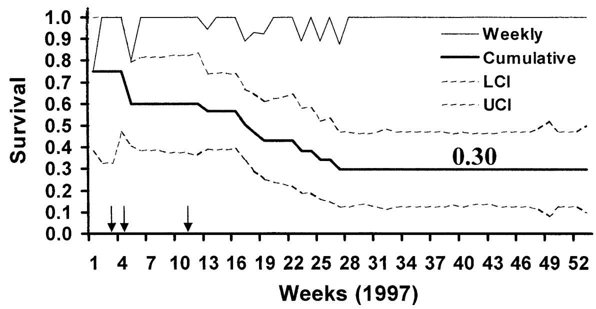

FIGURE 2. Weekly and cumulative survival rates of 24 captive-reared Hispaniolan Parrots released in 1997, Parque Nacional del Este, Dominican Republic. Estimates based on Kaplan-Meier estimator. LCI and UCI are the 95% lower and upper confidence intervals. Week 1 of the 53-week period used to estimate survival began on 14 September 1997 (first release); week 53 began on 18 September 1998. Three additional releases (indicated by arrows) occurred on week 3 (3 October), week 4 (10 October) and week 12 (8 December).

49%; Fig. 2). At 53 weeks postrelease, 12 parrots had died, seven were alive, and five were censored. Three of four groups lost at least one parrot 3–5 days postrelease (weekly survival, Fig. 2). Defining ''week of release'' for each group as week 1, two deaths were recorded 6–7 weeks postrelease, while the remaining occurred after 11 weeks. Raptors killed two parrots during weeks 6–7. The Mayfield daily survival rate for the same data set was 0.997, yielding a first-year survival rate of 35% (CI: 26–48%).

In contrast to 1997, none of the 25 Hispaniolan Parrots released in 1998 died within five days postrelease. In fact, all birds released on 29 June had already survived 10 weeks when Hurricane Georges hit Parque del Este on 22 September. Median keel scores for 1997 releases were significantly smaller (3.0) than for 1998 (3.5; median test, $\chi^2_1 = 13.4$, $P < 0.001$; $n = 49$), indicating that birds released in 1998 were in better physical condition. If early mortality during week 1 of 1997 could have been eliminated, as in 1998, the 1997 annual survival estimate would have been 65% (CI: 42–87%).

Only one bird was found dead 1–2 days after the passage of Hurricane Georges. The number of deaths peaked in December (five deaths), 10 weeks after the hurricane (Table 1). The Kaplan-Meier cumulative survival estimate at 16 weeks after the first release in 1998 (29 June) was 77%

TABLE 1. Survival of Hispaniolan Parrots released in 1998 in Parque Nacional del Este, Dominican Republic. Summary is broken down in approximately 2-week intervals from 29 June 1998 to 15 February 1999. Hurricane Georges made landfall in the study area on 22 September 1998. Survival, estimated using Kaplan-Meier (Pollock, Winterstein, et al. 1989), was not estimable after 15 November. ''Censored'' refers to parrots whose signal was not detectable but were not necessarily dead.

Time interval	Parrots tracked	Deaths	Censored	New releases	Cumulative survival	95% CI
29 June	8	0	0	0	1.00	1.00–1.00
16 July	8	0	0	0	1.00	1.00–1.00
1 August	8	0	0	0	1.00	1.00–1.00
16 August	8	0	0	0	1.00	1.00–1.00
1 September	8	0	0	17	1.00	1.00–1.00
17 September	25	1	6	0	0.96	1.00–0.80
1 October	19	0	4	0	0.96	1.00–0.87
16 October	15	3	5	0	0.77	0.95–0.58
1 November	6	0	14	0	0.77	1.00–0.47
16 November	4	0	16	0		
1 December	6	3	12	0		
16 December	3	2	13	0		
1 January	2	1	13	0		
16 January	1	0	14	0		
1 February	6	0	9	0		

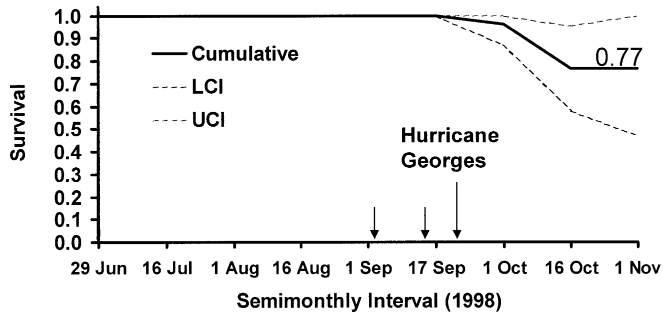

FIGURE 3. Cumulative survival rates of 25 captive-reared Hispaniolan Parrots released in 1998, Parque Nacional del Este, Dominican Republic. Estimates based on Kaplan-Meier estimator. LCI and UCI are the 95% lower and upper confidence intervals. Two additional releases (indicated by arrows) occurred on 3 September and 16 September 1998. Survival was not estimable using Kaplan-Meier after 15 November.

(CI: 88–95%). It dropped 23% in eight weeks since the passage of Hurricane Georges (Fig. 3). The first-year Mayfield survival estimate from 29 June 1998 to 1999 was 29% (CI: 14–64%).

The likelihood of survival increased with movement (Fig. 4). The relationship held for birds examined in the absence of the effects of Hurricane Georges ($\chi^2_1 = 10.4$, $P < 0.001$, $r^2 = 0.24$; $n = 34$) and for birds examined after the hurricane ($\chi^2_1 = 8.4$, $P < 0.01$, $r^2 = 0.34$; $n = 20$), although the latter moved greater distances. Movement among birds released in 1997 was higher for those that survived (9.8 ± 0.6 km) than for those that died (5.7 ± 1.0 km; $t_{18} = -2.2$, $P < 0.001$). Movement by birds released in 1998 (prior to Hurricane Georges) was significantly higher (16.9 ± 3.1 km) than by birds released in 1997 that either died ($t_{19} = -2.3$, $P = 0.03$) or survived ($t_{20} = -2.2$, $P = 0.03$). Posthurricane movement was significantly higher (26.6 ± 3.4 km) than before the hurricane (11.0 ± 2.5 km; $t_{11} = -4.9$, $P < 0.001$).

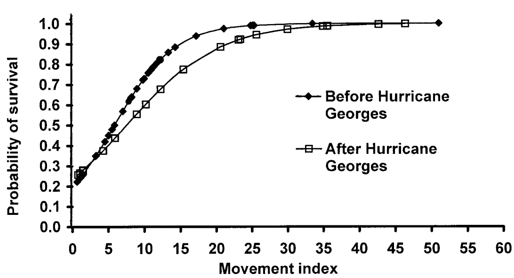

FIGURE 4. Relationship between likelihood of survival and movement index of captive-reared Hispaniolan Parrots released in Parque Nacional del Este, Dominican Republic. Movement index is a measure of sequential, one-way movements of individuals from release sites, expressed in kilometers. Solid symbols depict relationship for parrots in 1997 and 1998, before Hurricane Georges. Unfilled symbols depict the relationship for parrots only after Hurricane Georges.

Fruit abundance declined following Hurricane Georges ($\chi^2_1 = 409.9$, $P < 0.001$, Fig. 5). Defoliation was extensive and trees were virtually devoid of fruit for up to four months after the hurricane. *Bucida buceras* produced most of the available fruit after the hurricane when compared with production before the hurricane (Fig. 5).

DISCUSSION

The 30% annual survival for captive-reared Hispaniolan Parrots in 1997 was markedly lower than the 83% reported for Yellow-shouldered Parrots (*Amazona barbadensis*; Sanz and Grajal 1998). The differences may be due to species and habitat differences and the fact that Yellow-shouldered Parrot chicks were brought to captivity from the wild. Whatever the basis, we were encouraged by the possibility that captive-reared Hispaniolan Parrots could have attained higher survival rates. In 1997, 41% of all deaths were recorded 3–5 days postrelease. These early deaths were eliminated in 1998. When all early postrelease deaths were removed from 1997 data, the hypothetical annual survival estimate was 65%. Gains in cumulative survivorship have important conservation implications because they may expedite recovery and offset mortality caused by factors such as raptors (e.g., Lindsey et al. 1994), or absence of wild birds (Lambert et al. 1992).

Survival probabilities increased with increasing mobility. Mobility likely facilitates locating food

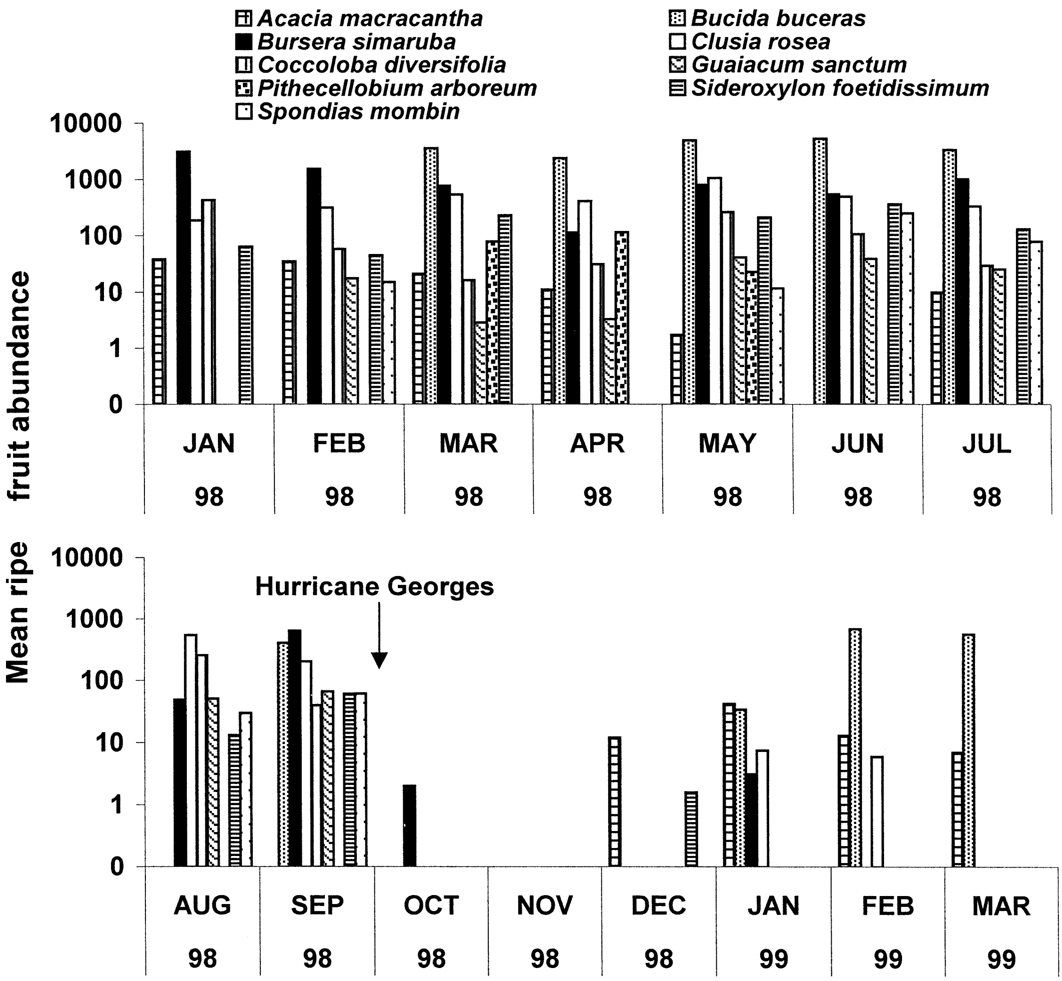

FIGURE 5. Monthly patterns of fruit abundance for nine plant species used as food by Hispaniolan Parrots in Parque Nacional del Este, Dominican Republic. Ripe-fruit abundance was estimated for each species by placing the number of ripe fruits in 10 trees in each of two transects into nine abundance categories, and then calculating the mean of the midpoints of the categories.

resources and avoiding predators (Snyder et al. 1987, Beck et al. 1994). The increase in mobility was noteworthy in 1998, when no deaths were recorded in the days following the release of birds. Although effects are confounded, two modifications to prerelease protocols may have contributed to interannual differences in early survival. In 1998, we subjected birds to a more rigorous exercise routine because we noticed that birds released in 1997 were not keeping up with wild birds. We detected a significant increase in keel muscle scores in 1998, which we interpreted as an improvement from increased exercise. Improved flight muscle condition is not the only factor influencing local movements, but it could have contributed to higher mobility. The second prerelease modification consisted of reducing the amount of blood collected from birds prior to release. The presumption was that bleeding birds just prior to release could only hamper their performance after release. Although parrots can replace 2 mL of blood within 3–7 days (K. Joyner, North Carolina State University, pers. comm.), prudence dictates that any intervention that could compromise postrelease survival should be minimized or eliminated.

The Mayfield first-year survival estimate for birds released in 1998 was 29%, remarkable considering that Hurricane Georges affected their survival probabilities. Hurricanes affect survival rates immediately and protractedly due to habitat degradation (Wiley and Wunderle 1992). The immediate impact of Hurricane Georges was low considering that 32 radio-tagged parrots were exposed to the hurricane on 22 September (25 from 1998; seven from 1997). We documented only one immediate posthurricane death. Other species (e.g., Puerto Rican Parrot) have lost as much as 50% of the population by the immediate impact of a hurricane (Vilella and Arnizaut 1994). A reduction in food resources was probably important in the ensuing deaths. None of the parrot remains encountered after the hurricane indicated that raptors were the cause of death. We cannot discard the possibility of diseases.

In support of our food limitation contention, we documented a marked reduction in food abundance for paired periods before and after the hurricane. We could not match fruit abundance data collected between late October and December 1998 to the same period in 1997 because phenology data were not collected then. Circumstantial evidence, however, suggests that the scarcity of fruits between October and December 1998 was likely due to hurricane impacts, such as defoliation (see Waide 1991), and not to seasonality. In the fall of 1997, we observed parrots consuming fruits of plants such as *Clusia rosea*, *Coccoloba diversifolia*, and *Bucida buceras*, which led us to monitor their phenology, and we fed these fruits to parrots during prerelease training in 1997. The diet of parrots is diverse, and fruits like *Clusia* are important because of their high lipid or amino acid contents (Wheelwright et al. 1984, Snyder et al. 1987). Studies in similar habitats in Puerto Rico report that species like *Clusia rosea*, *Coccoloba* spp., *Guaiacum* spp., *Pithecellobium arboreum*, and *Bucida buceras* produce fruit during fall (Little and Wadsworth 1964, Lugo et al. 1978). It was noteworthy that birds moved farther after the hurricane when compared to movement patterns in the absence of a hurricane. This pattern of traveling greater distances to secure food was consistent with changes in mean $\pm$ (SE) home-range size (all birds) recorded before (915 $\pm$ 79 ha) and after the hurricane (1218 $\pm$ 230 ha; Collazo et al. 2000).

Our study underscores the value of standardizing prerelease protocols, and of estimating survival rates and their possible relationship to factors such as mobility of birds from the release area. Our findings strongly suggest that prerelease conditions influence the mobility of captive-reared birds. Carefully designed tests will provide a sound foundation to make decisions about the need for adjustments in a release program. Another value of estimating survival and measuring habitat correlates was the opportunity to assess the ecological basis of population changes. We were able to quantify the sources of mortality in the aftermath of a hurricane, which had not been possible in previous avian studies in the Caribbean. Standardized prerelease protocols and tests that evaluate the success of releases (e.g., survival) should be used in pssittacine restoration programs that depend on captive-reared individuals.

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