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The use of hand-raised psittacines for reintroduction: a case study of scarlet macaws (*Ara macao*) in Peru and Costa Rica

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Abstract

This study reports on three scarlet macaw (*Ara macao*) reintroduction projects using hand-raised birds in Peru and Costa Rica. The habitats at the release sites ranged from pristine tropical forest to forest fragments in an agricultural matrix. The combined first-year survival was 74% and the annual post first-year survival was 96%. Survival rates were very high despite a wide range in predator communities. Number of birds released explained 70% of the variation in survival with birds from larger releases having higher survival rates. Behavioral evidence suggests that birds established at the site facilitated survival of later releases. Breeding attempts were recorded at all three sites and hand-raised birds with wild mates successfully fledged young in Peru. Supplemental feeding post-release played an important role in keeping the birds near the release site and facilitating social interactions. This work shows that properly socialized hand-raised macaws can survive and breed in the wild but that ex-pets are not good release candidates.

Keywords: Reintroduction; Macaw; Psittaciformes; Supplemental feeding; Peru; Costa Rica; Captive breeding; Disease; Hand-raised; Socialization

1. Introduction

Captive breeding and reintroduction are important management tools for endangered species (Balmford et al., 1996; Noss, 2001). However these projects are expensive, have a high risk of failure and are usually not properly documented, making it impossible to learn from the successes and mistakes of others (Griffith et al., 1989; Beck et al., 1994; Biggins et al., 1999). The role of captive breeding and reintroduction has been hotly debated especially in the field of parrot conservation in part because parrots are susceptible to various lethal, contagious diseases that may lie dormant for years (Clubb, 1992; Derrickson and Snyder, 1992; Wiley et al., 1992; Balmford et al., 1996; Snyder et al., 1996, 1997; Gippoliti and Carpaneto, 1997). The family Psittacidae contains the highest proportion of species at risk of extinction of any large avian family yet many are kept and bred in captivity (Clubb and Clubb, 1992a; Johnson, 1992; Bennett and Owens, 1997; Collar, 1997). This provides many opportunities for reintroduction by private and public institutions (Clubb and Clubb, 1992b; Snyder et al., 1994; USFWS, 2002; Collazo et al., 2003; Juniper, 2003). Captive-raised animals usually perform poorly in comparison to wild-caught individuals but studies must continue to evaluate the potential of captive-raised birds because translocation is not an option when wild populations are endangered or extinct (Griffith et al., 1989; but see Sanz and Grajal, 1998; Collazo et al., 2003).

The scarlet macaw (*Ara macao*) is widely distributed throughout tropical America (Forshaw, 1989). The bird

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was formerly quite common but habitat loss, hunting and capture for pets have caused drastic declines and extinction in many areas, most notably Central America (Wiedenfeld, 1994; Juniper and Parr, 1998; Renton, 2000). This study compares three scarlet macaw release projects to document the techniques used and determine what factors correlate with high survival rates.

2. Study areas

Curú National Wildlife Refuge is a working farm located on the Nicoya Peninsula, in western Costa Rica (09°47′N, 84°56′W, elevation:sea level). It covers 1492 ha: 70% is natural forest and 30% human-created habitats (Schutt and Vaughan, 1995). Rainfall is strongly seasonal and totals 2000 mm per year. The site is a mix of tropical dry and tropical most forest (Holdridge, 1967). There are no large raptors able to kill adult macaws. Wild scarlet macaws disappeared in the late 1960s.

The San Josecito Valley Center for Release is in a 200 ha valley approximately 16 km north of Golfito, Costa Rica (08°37′N, 83°15′W, elevation:sea level). Rainfall is aseasonal and totals about 6000 mm per year. This site will be referred to as Golfito. The valley floor is second growth forest ringed on three sides by low mountains covered in primary tropical wet forest. Golfo Dulce borders the fourth side. Adjacent to the valley is Piedras Blancas National Park (15,000 ha). Scarlet macaws were extirpated in the late 1950s (Janik et al., 2003). There are no large eagles at the site and *Spizatus* hawk-eagles occur at very low densities.

Tambopata Research Center (13°07′S, 69°36′W, elevation: 250 m) is located in SE Peru on the border between the Tambopata National Reserve (275,000 ha) and the Bahuaja-Sonene National Park (537,000 ha) over 20 km from the nearest permanent human settlement (Foster et al., 1994). Rainfall totals 3200 mm and is weakly seasonal (Brightsmith, in press). Primary tropical moist forest, *Guadua* bamboo patches and riparian successional forest of differing ages surround the site (Griscom and Ashton, 2003). The area has populations of large macaws (*Ara ararauna*, *A. chloroptera* and *A. macao*) and large raptors (*Harpia harpyja*, *Morphnus guianensis*, *Spizatus tyrannus*, *Spizatus ornatus* and *Spizastur melanoleuca*, Foster et al., 1994).

3. Methods

3.1. Rearing

Release candidates were captive-raised from native stock in Alajuela Costa Rica at Zoo Ave (Golfito) and Amigos de las Aves (Curú) or rescued from nests of wild birds (Tambopata, Table 1). Hand-raised birds were hatched in incubators or raised by their parents up to 2 weeks before being removed for hand raising. Seven Golfito birds were raised to fledging by their parents. At Amigos de las Aves no attempt was made to isolate the birds from casual human contact. At Zoo Ave the chicks were isolated from most human contact and visited only during feeding. The birds at both facilities were weaned off of hand feeding around 100 days when they were

Table 1
Summary of methods used in three scarlet macaw releases in Latin America

	Curú, CR	Golfito, CR	Tambopata, Peru
General			
Source of birds	Captive breeding	Captive breeding	Wild nests
Age at release	1.7–3.7 years ($x = 2.7$)	?	90–100 days
Pre-release methods			
In flight cages pre-release	Yes	Yes	No
Predator conditioning pre-release	No	No	No
Disease screening pre-release	Yes	Yes	No
Disease detected	[a]	No	*Salmonella*
Kept with conspecifics during rearing	Yes	Yes	Yes
Feeding			
Hand fed pre-weaning	Yes	Yes	Yes
Hand fed post-weaning	No	No	Yes
Fed wild local foods pre-release	Yes	Yes	No
Supplemental feeding post-release	Yes	Yes	Yes
Interactions with people			
Isolated from contact during rearing	No	Yes	No
Given affection pre-fledging	Yes	No	Yes
Given affection post-fledging	No	No	Yes
Approach people post-release	No	No	Yes

[a] See text for discussion of *Chlamydiophila* [*Chlamydia*] *psittaci* testing here.

placed in small flight cages and learned to feed themselves. The birds were in groups at all times throughout raising. Post-weaning contact with humans was minimal. Five confiscated ex-pets were given to Zoo Ave and included in the releases. These birds were probably 2–5 years old and were removed from the wild as chicks (Janik et al., 2003). All birds were marked with individually numbered metal leg bands.

In Tambopata younger chicks were removed for hand-raising from natural and artificial nests at age 5–15 days from 1991 to 1993 (Nycander et al., 1995). In 1994, the second and third eggs were taken and incubated in the lodge. In all years, pairs of chicks were raised in small boxes (35 cm on a side) and not isolated from casual human contact.

3.2. Health screening and disease

Veterinarians conducted general fitness exams (Curú and Golfito), blood tests (Curú and Golfito) and general fecal exams (Golfito). All tests came up negative in Golfito (Janik et al., 2003). In Curú, all birds tested disease-free before transport to the release site, but after arrival one bird tested positive for *Chlamydiophila* [*Chlamydia*] *psittaci*. The bird was sacrificed and a necropsy showed no evidence of disease. The bird was one that had not been raised in the Amigos facility. The result may have been a false positive or indicate exposure to *Chlamydiophila* before being acquired. In Tambopata no pre-release health screenings were performed. In 1994 researchers found 7 of 17 (41%) hand-raised birds tested positive for *Salmonella* but none of the wild birds did. Karesh et al. (1997) conclude that the source of the infection was live and dead chickens used to feed the researchers and visitors.

3.3. Pre-release training

At both Curú and Golfito macaws were held in aviaries at the release site for at least 6 months. The birds were fed a mixture of basic diet (fruits, rice, beans, dog food, etc.) and wild foods. At Tambopata the birds received little pre-release training. Formal predator aversion training was not done at any of the sites however two Golfito birds were killed in the pre-release cage by a *Leopardus pardalis*, which made the survivors wary of terrestrial mammals.

3.4. Releases

At Curú pairs and trios of birds were released over 17 days starting on 7 January 1999. Most birds left the immediate area upon release but returned within 1–5 days. At Golfito birds were released on 14 different dates from May 1999 to December 2001. At Tambopata birds were not held in cages and releases consisted of individual fledging age birds (80–100 days) flying in to the forest. Tambopata birds took 12 h to 3 days to return to the lodge to be fed (AC).

3.5. Survey techniques

At all three sites, supplemental feeding post-fledging played a vital role in surveying the populations. Birds received a standard diet similar to what they were raised on for 2 months (Curú), and 10 months (Tambopata) post-release. At Golfito standard diet items were available continuously due to the regularly spaced release events. By the end of the first year the birds obtained nearly all their calories from wild foods, but supplemental feeding of a few highly preferred items (sunflower seeds in Curú and Golfito, crackers and bananas in Tambopata) continued throughout the study.

At Curú researchers did not identify individual birds but counted the total number of individuals on a daily basis. In Golfito birds were marked for individual identification using black ink on the bill, small cuts in the tail feathers and radio collars (Janik et al., 2003). Birds were censused daily at feeding stations and opportunistically at nest boxes. Eighteen of 38 birds (47%) were equipped with radio collars (Holohil, model AI-2C, Bjork and Powell, 1995). These collared birds were monitored daily for the first two weeks post-release, once a week for the first 3 months and irregularly thereafter. This study reports on sightings at Golfito through December 2002.

In Tambopata, birds were marked with leg bands that could not be read from a distance. Individuals were identified at the lodge and at nests during January–May 1994 (AC), February–March 1998 (AC), May–August 1998 (AC), September 1999 (DB), and November 1999–March 2000, 2001, 2002 (DB and assistants). Researchers monitored seven natural and 12–17 artificial macaw nest sites during November–March each year from 1999 to 2002.

Birds that dispersed away from the release site and did not return were classified as mortalities. While this method obviously underestimates survival it is appropriate where the goal of reintroduction is to establish a new population.

3.6. Data analysis

We calculated mean and variance of daily survival rates for released macaws following Mayfield (1975) and tested differences in survival rates using a Z-test (Hensler and Nichols, 1981). The P-values of these tests were corrected using a sequential Bonferroni analysis with overall $\alpha = 0.05$ (Sokal and Rohlf, 1995). All birds released in the same month were considered part of the same release. Our data violated the assumption that survival probabilities were independent among individuals so we used a grouped logistic regression where the release was the basic unit of analysis (Cox and Snell, 1989). The variables number released, number established at the site before the release, and site were included as independent variables in the model and the Mayfield first year percent survival was used as the dependent variable. Annual Mayfield survival rates were calculated as (mean daily survival rate)^{364}. Variables that did not contribute significantly to the model were eliminated and the analysis rerun. Since proportions become unstable and highly variable with small denominators, we excluded releases with <3 birds from the regression analysis (Pyle et al., 1993). Data are presented as mean ($\bar{x}$) ± standard deviation (SD).

4. Results

4.1. Survival

Seventy one scarlet macaws were released and the overall survival rate was 89% per year. At Curú 10 of the 13 birds (77%) were still alive 4 years after release. At Golfito 34 birds were released including 22 hand-raised, seven parent-raised and five confiscated ex-pets. Four birds were released, captured and released again resulting in 38 release events. Of the 38 releases, 63% were alive and returning to the release site through December 2002. At Tambopata a total of 20 scarlet macaws were released from 1992 to 1995 (release age 80–100 days). Of these 55% were still alive as of March 2002.

For all birds combined, the first-year survival rate was 74% and the annual post first-year survival rate was 96% (Table 2). The overall daily survival of birds at Golfito was lower than the daily survival rate for Curú ($x_{\text{Golfito}} = 0.999319 \pm 1.8 \times 10^{-4}$, $x_{\text{Curú}} = 0.999825 \pm 1.01 \times 10^{-4}$, $Z = 2.43$, $P_{(\text{Bonferroni corrected})} = 0.03$) and Tambopata ($x_{\text{Tambopata}} = 0.999815 \pm 6.5 \times 10^{-5}$, $Z = 2.57$, $P_{(\text{Bonferroni corrected})} = 0.03$). First year daily survival rates at Golfito were significantly lower than at Curú ($x_{\text{Golfito}} = 0.998624 \pm 3.8 \times 10^{-4}$, $x_{\text{Curú}} = 0.999773 \pm 2.27 \times 10^{-4}$, $Z = 2.59$, $P_{(\text{Bonferroni corrected})} = 0.03$). First-year daily survival rates did not differ significantly between Golfito and Tambopata ($x_{\text{Tambopata}} = 0.999529 \pm 2.7 \times 10^{-4}$, $Z = 1.93$, $P_{(\text{Bonferroni corrected})} = 0.104$). Post first-year daily survival rates did not vary significantly among sites (Table 2).

A total of 11 independent releases were conducted ranging in size from 1 to 13 birds. Due to small sample sizes (<3 birds) three releases were eliminated from the statistical analyses. The Mayfield first-year survival of released macaws was positively correlated with the number of birds released (Fig. 1, grouped logistic regression: $n = 8$ releases, $r^2 = 69.1$, $\chi^2 = 9.15$, $v = 1$, $P = 0.0025$). The field site (Golfito, Curú or Tambopata) did not contribute significantly to the model (grouped multiple logistic regression: $\chi^2 = 3.2$, $v = 2$, $P = 0.2$), nor did the number of released birds previously established at the site (grouped multiple logistic regression: $\chi^2 = 0.4$, $v = 1$, $P > 0.5$).

4.2. Breeding behavior

At all three sites birds have formed pairs: Curú 3 pairs, Golfito 5 pairs and Tambopata all 11 surviving hand-raised birds have wild mates. Nest boxes at all sites have been investigated by released macaws and used at both Golfito and Tambopata. At Golfito five different pairs have defended artificial nests and at least one pair laid eggs. At Tambopata hand-raised birds and their wild mates nested successfully. In total six such pairs have defended nests, five laid eggs, and three fledged a total of four chicks. At Curú pairs have apparently attempted to nest in natural tree cavities in two different years but no chicks have been produced. Researchers have not monitored nests at Curú or Golfito so causes of nest failure there are unknown. At Curú and Golfito it was not known which individuals attempted breeding. The approximate ages for first breeding attempts at all sites are Curú 4–7 years, Golfito 5–6 years (Janik et al., 2003), and Tambopata 7.2 ± 0.8 years ($n = 4$).

4.3. Reactions to humans/habituation

Released birds showed little fear of humans. At Curú, birds could be approached within 4–5 m (DB pers. obs.) while at Golfito birds would allow people within 8 m (Janik et al., 2003). No birds at Golfito or Curú approached people in search of food (Table 1). At Tam-

Table 2
Macaw survival at three release sites[a]. Mortalities are the number of birds that died or disappeared >1 year after release. Birds that left the release area and were never seen again were considered mortalities. The years monitored indicates the number of years the birds were monitored starting with the release of the first bird

	Released	First-year survival (%)	Annual survival post first-year (%)	Mortalities post first-year	Years monitored
Curú	13	92	96	2	4.2
Golfito	31	60	98	1	2.7
Tambopata	20	84	96	5	10
Total	64	74	96	8	16.9

[a] Survival rates are calculated using the Mayfield method (Mayfield, 1975).

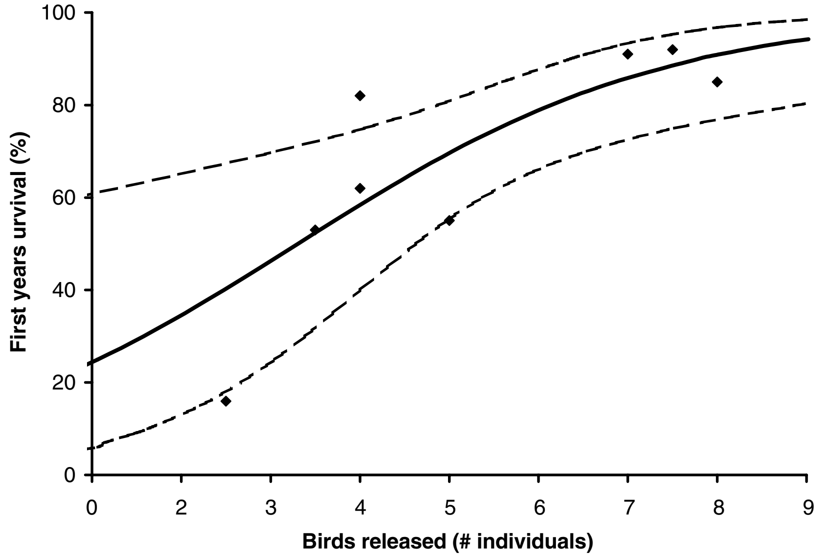

Fig. 1. First year survival of scarlet macaws (*Ara macao*) in relation to the number of birds released (grouped logistic regression: $n = 8$ releases, $r^2 = 69.1$, $\chi^2 = 9.15$, $v = 1$, $P = 0.0025$). Three releases of <3 birds were not included in the analysis. First year survival was calculated using the Mayfield (1975) method. The curves show the fitted values and 95% confidence interval from the regression analysis.

bopata birds had no fear of humans and regularly approached people for food.

Three of the five ex-pets released in Golfito associated more closely with humans. Although no quantitative data exist, they apparently socialized less with the other released macaws, strayed less from the immediate release area, perched lower in the trees near the staff area and occasionally walked on the ground. Despite these apparently maladaptive behaviors, all 5 ex-pets survived at least 2 years post-release.

5. Discussion

5.1. Survival

This study shows that hand-raised scarlet macaws can survive in the wild in a range of abiotic and biotic conditions and that larger releases were more successful than smaller ones. Survival in Golfito was lower than at the other two sites apparently due to the small average release size and the delay in establishing a core flock. The first-year survival of reintroduced parrots is usually well below 50% so our 74% survival was greater than expected (Snyder et al., 1987, 1994; USFWS, 2002; Collazo et al., 2003; but see Sanz and Grajal, 1998). The high first-year survival may be due in part to intrinsic qualities of scarlet macaws. The species lives in a wide range of habitats (Forshaw, 1989) and retains high levels of genetic diversity (Nader et al., 1999). In addition the released birds were only in captivity for 2 generations or less reducing the time for domestication (Wiley et al., 1992). If similar releases were tried with an endangered habitat and diet specialist with low genetic heterozygosity the results may not have been as positive (Griffith et al., 1989).

Wild predators can rapidly decimate groups of reintroduced organisms especially when the release candidates are captive-raised and lack appropriate anti-predator responses (Snyder et al., 1994; Sinclair et al., 1998). In both Curú and Golfito, the large eagles and hawk-eagles were either extinct or at such low densities as to be irrelevant to the release efforts. Tambopata has 5 raptor species large enough to take adult macaws but this did not result in low survivorship possibly due to naïve birds learning from the wild population. Of great relevance to future macaw releases is the fact that avian predators large enough to capture adult macaws occur at naturally low densities and are usually rare or extinct where humans have eliminated macaw populations (Willis and Eisenmann, 1979; Terborgh et al., 1990; Thiollay, 1994; Stotz et al., 1996; BirdLife International, 2000). This may allow large macaws to avoid high rates of predation that have plagued reintroductions of smaller Psittacines like Puerto Rican and Thick-billed Parrots (Snyder et al., 1994; USFWS, 2002).

Ninety percent of the macaws released for this study were hand-raised. In both Curú and Tambopata the hand-raising was supplemented with frequent human contact. Based on the traditionally poor performance of captive-raised animals, the high survival rates found here were surprising (Griffith et al., 1989; Beck et al., 1994; Snyder et al., 1994). In both Curú and Golfito the birds adapted to life in the wild in the absence of an established wild population (see Lima and Sampaio, 2002 for similar results with *Aratinga* parakeets).

As has been found elsewhere, larger releases were more successful than smaller ones (Snyder et al., 1994; Wolf et al., 1998). For this reason future macaw and parrot releases should involve as many birds as is feasible. The number of birds established at the site before release did not significantly correlate with higher survival but anecdotal evidence suggests that this may be important. An eagle killed the first bird released at Tambopata but after the establishment of a core flock, eagle arrivals prompted released birds to alarm call and fly to the lodge for safety (AC pers. obs.). In Golfito the first bird that became established at the release site reentered the cage where the other macaws were being held. Also at Golfito many birds from the first releases left the site and never returned. After the establishment of the core flock, new releases that left returned accompanying the flocks of established birds. This is similar to the behavior of blue-and-yellow macaws released on Trinidad (Oehler et al., 2001 as corrected by B. Plair pers. com.). Social interactions among Hispanolan Parrots were also important as the presence of birds from earlier releases facilitated the integration of new releases into flocks (Collazo et al., 2003).

Maintaining social interactions among released birds and establishing core flocks appear to be important to the success of parrot releases. Our experience suggests that extended periods of supplemental feeding promoted social interactions among the flock members; encouraged birds to stay in protected areas; allowed project personnel to monitor survival and reproduction; and allowed new releases to quickly find and join the established flock (see also Casimir et al., 2001). Release guidelines for parrots recommend that feeding be conducted only until birds are self-sufficient (Snyder et al., 2000). We suggest that releases continue supplemental feeding even after it is considered superfluous for nutritional reasons. However, care must be taken to ensure that the feeding does not increase predation risk or create birds that approach humans for food (Snyder et al., 1994).

5.2. Reproduction

The key to successful establishment of new populations is reproduction. Successful breeding has taken place only in Tambopata and here hand-raised birds bred with wild mates. In Costa Rica, pairs defended nests (Curú and Golfito) and laid eggs (Golfito). Given the breeding attempts recorded so far there is no a priori reason to think that pairs will not breed at all sites. However, it is unclear if reproduction will be sufficient to allow the populations to grow and expand as hoped. In both Curú and Golfito future releases are scheduled to include more parent raised birds, which may have higher reproductive success (Meyers et al., 1988).

5.3. Raising birds for release

Many hand-raised animals lack the social skills needed to survive and reproduce in the wild (Snyder et al., 1987, 1994; Wiley et al., 1992; Snyder and Snyder, 2000). At all sites our birds formed coherent flocks, formed stable pairs and attempted to breed (see also Sanz and Grajal, 1998; Casimir et al., 2001; Lima and Sampaio, 2002). Our birds probably showed adequate social behavior because they spent significantly more time during the raising process socializing with macaws than with humans (Styles, 2001). In our work the only birds that showed inappropriate social behaviors were confiscated ex-pets who were probably raised in close contact with humans and isolation from conspecifics.

Lack of fear of humans is dangerous as local people often capture or kill released parrots (Snyder et al., 1987; Clubb and Clubb, 1992b; Wiley et al., 1992; Oehler et al., 2001). All birds released in our studies seemed to be more tolerant of humans than wild birds. The Tambopata birds approached humans because they were hand-fed long after weaning age (Table 1). At Curú and Golfito birds did not approach people presumably because weaned birds were kept in cages where they learned to eat food from feeders, not directly from caretakers.

Infectious disease concerns are often cited as the key reason not to conduct releases of captive parrots (Wiley et al., 1992; Snyder et al., 1996). Diagnostic tests for important psittacine diseases such as psittacosis (*Chlamydiophila psittaci)*, avian polyomavirus, and psittacid herpesvirus 1 (Pacheco's disease) may not always detect these agents. Additionally, diseases such as proventricular dilatation disease (wasting disease) are of unknown etiology and no diagnostic test exists. Unfortunately these diseases may remain sub-clinical until stress precipitates an active infection or a susceptible host is infected after contact (Altman et al., 1997; D. Styles pers. com.). As a result, appropriate biosecurity measures should be instituted to ensure that release candidates are protected from infectious disease. In Tambopata, the most remote of the three release sites, hand-raised birds contracted *Salmonella* during the rearing process (Karesh et al., 1997). Additionally at Curú, the one bird that tested positive for psittacosis was not raised at the Amigos de las Aves facility. This emphasizes the potential risk of using birds from insecure sources and reaffirms that all release programs must have strict quarantine, biosecurity, and disease testing regimens to ensure the production of disease free release candidates (Snyder et al., 1996). The threat of spreading infectious diseases from captive to wild populations exists and therefore releases should not be conducted in areas with viable populations of wild conspecifics.

The release of ex-pet parrots in to the wild is often considered by conservation-minded pet-owners. Our experience shows that ex-pets are the worst candidates for release due to their failure to interact appropriately with other macaws and their propensity to stay near humans. In addition confiscated birds, be they wild caught or ex-pets, are always a disease risk. Birds that are poached or held in homes are often kept in poor conditions, fed improper diets and exposed to other captive wild birds or domestic fowl (Nilsson, 1981). These are ideal conditions for the development of serious diseases.

The results from these case studies show that properly socialized hand-raised scarlet macaws survive in the wild. The high survival rates found here may be due to the innate adaptability of scarlet macaws and inherently low predation rates on these large birds. No pairs of released captive bred birds have reproduced successfully so it is uncertain if these populations will become self-sustaining. While these results may not be duplicable with all species, the current study shows that captive breeding and reintroduction can be used to reestablish psittacines in areas from which they have been extirpated.

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