# The Tambopata Macaw Project:

## Developing techniques to increase macaw reproductive rates

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## Introduction

Large macaws are among the most spectacular and revered birds in the world. Unfortunately, they are disappearing from many areas of the tropics. For example the Guayaquil subspecies of the Great-green or Buffon's Macaw (*Ara ambigua guyaquilensis*) is in imminent danger of extinction (K. Berg pers. com.). In Costa Rica, the Great-green Macaw (*A. a. ambigua*) has been eliminated from 80% of its former range and only an estimated 200 remain (Powell et al in prep.). In Bolivia the Blue-throated Macaw (*Ara glaucogularis*) has been reduced to less than 200 individuals (Hess 1999). In addition, all the blue macaws, Glaucus, Lear's, Hyacinth and Spix's, are either extinct or gravely endangered (Collar 1997, Juniper and Parr 1998). As a result, there is an urgent need to aid the recovery of macaw populations. The work described here uses three species of large macaws in Peru as a model system to develop techniques that can be used to help the recovery of other macaw species throughout the New World tropics.

The threats that face macaws are many and include habitat loss, hunting and collecting for the pet trade. Habitat loss takes many forms including clearing for agriculture, cattle ranching and logging. Agriculture, ranching and the subsequent human settlement eliminates the majority of the vegetation but in some instances may leave sufficient food resources to support populations at least over the short term. Tropical logging operations are usually very selective, targeting first the largest examples of marketable trees. This leaves a large amount of vegetation standing including many possible food trees. Macaws are dependant on large, pre-existing tree cavities for nesting. In many instances the nest trees they use may be hundreds of years old and even in virgin forests the lack of suitable nest trees limits the number of macaws that can breed each year (Munn et al. 1991). Logging operations that target these large trees do insidious damage to macaw populations. The forests may look health and still have relatively large numbers of macaws, but without suitable nesting sites, the macaw population is doomed to decline to extinction.

Collection for the pet trade is a major threat to nearly all populations of large macaws (Juniper and Parr 1998). Collection techniques are varied and can target either adults or chicks. Adults are captured in a variety of ways either for food, feathers or to be sold as pets. Snares are placed on suitable perches. In Ecuador collectors set fires at the bases of nests and the smoke is used to knock out or kill the adults (J. Socola pers. com.). In some cases adults are shot in the wing while flying and collected alive. The collection of young for sale is more common than the collection of adults. This is due mostly to the higher demand for young because of the fact that they make better pets. The number of macaws taken from the wild can be considerable. At this point it is thought that there are more Blue-throated Macaws in captivity than in the wild, and rumors exist of a single shipment of nearly 200 of these macaws. If this is true, this one shipment alone contained more birds than the current wild population. When young are collected they are taken from nests in a variety of ways. Collectors often free-climb or use a combination of ropes and ladders to get to the nest holes and remove the young. When the collectors cannot gain access to the nests they often cut the entire tree to remove the young. The fall results in the death of up to 60% of the chicks (González 1999). Collection for the pet trade is blamed for the disappearance of large macaws from many areas. This direct damage is compounded by the cutting of nest trees by collectors, the natural scarcity of suitable trees and further removal of large trees by logging operations. These forces have combined to leave the macaws that do remain with few opportunities to nest. As a result, it is clear that just declaring new protected areas may be insufficient to allow macaw populations to recover from the decades of collection and tree cutting.

Previous research in southeastern Peru has shown that macaw reproductive rates in undisturbed areas are extremely low. This is due to three main factors: 1) suitable nesting cavities occur at a density of only one per 15 – 20 ha, 2) only about 60% of nests fledge young as predators and parasites combine to kill many chicks, and 3) successful nests usually fledge only one young even when 3 or 4 eggs are laid and the other chicks die of malnutrition (Munn et al. 1991, Nycander et al. 1995). As a result, a population of 200 macaws may produce as few as 8 young per year. From 1989 – 1993 work was conducted at Tambopata Research Center, Peru to develop techniques to increase the reproductive rates of wild macaws (Nycander et al 1995). During this 4 year study researchers 1) developed techniques to use live palm trees to create nest sites for Blue-and-gold Macaws, 2) constructed artificial nest boxes for use by Scarlet Macaws, and 3) rescued, hand-raised and released Blue-and-gold, Scarlet and Green-winged Macaw chicks. All of these resulted in great increases in the reproductive output of these three species in the area surround Tambopata Research Center.

The current project is a continuation of the 1989 study. The goal of the current project is to document the state of the work begun in the early 1990's and develop additional techniques to increase the reproductive output. In particular the goals are to monitor the use and persistence of palm trees used by Blue-and-gold Macaws, monitor the use of artificial and natural nests by Scarlet and Green-winged Macaws, monitor the survival and reproduction of the hand-raised macaws. In addition the project seeks to develop new methods to save chicks that are doomed to starvation that do not require hand-raising. An alternative to hand-raising is of interest because the hand-raised chicks released at TRC have no fear of humans and are inclined to approach people looking for food. As a result the birds raised in this way could not be released in an areas near population centers where there is a risk of them being captured or killed by people.

## Methods

### *Study Area*

The study site is Tambopata Research Center (TRC) located in the extreme western edge of the Amazon basin at the base of the Andes Mountains in southeastern Peru. The center is located 50 meters from the Tambopata River deep inside the 1.5 million hectare protected area composed of the Tambopata-Candamo Reserve Zone and Bahuaja-Sonene

National Park. The site is covered with tropical moist forest with a canopy of 30 – 35 meters and occasional emergent trees rising to 55 – 60 meters (Terborgh 1983, Munn et al 1991). The area boasts healthy populations of three species of large macaws, Blue-and-gold (*Ara ararauna*), Green-winged (*A. chloroptera*) and Scarlet (*A. macao*). The center is located a few hundred meters from a large clay lick where up to 250 macaws can be seen coming to take clay (Munn et al 1991). The abundance of macaws in the area makes this site an ideal location to develop new management techniques as there are sufficient individuals to obtain relatively large sample sizes.

***Palm tree nesting***

In the early 1990's when researchers first arrived at Tambopata Research Center Blue-and-gold Macaws were common visitors to the adjacent clay lick, but none nested in the immediate vicinity. In other areas the species nests in dead palms, especially in the large palm swamps dominated by the aguaje palm, *Mauritia flexuosa* (González 1999). Researchers located a small palm swamp near TRC but there were no suitable dead trees for nesting. In 1992 the team developed a technique to cut the tops off the palm trees in the hopes of attracting nesting macaws (see Nycander et al 1995 for additional details). Cutting off the top exposes the soft center of the palm to water, fungus, and beetles that all combine to rot the center away and leave only the hard outer layers of the palm. This produces deep tubes useable by nesting macaws. Once the palms rotted out to a point where they were deep enough, the Blue-and-gold Macaws began to use them (Nycander et al 1995). Since 1992, a total of 42 palms have been cut and they have been used extensively by both Blue-and-gold Macaws and Red-bellied macaws (*Orthopsittaca [Ara] manilata*).

Starting in November 1999, nests in the palm swamp were checked every 7 – 10 days. This was accomplished by observing the nest for 4 or more hours in the evening. During these observations it was noted which nests had activity. The following day the contents of all active nests were checked. Due to the fragile nature of the dead palms and the depth of the nest cavities, the chicks could not removed from the nests. Instead the nests were checked by looking down in to the nests from the top using a combination of flashlights and mirrors as needed.

***Nest boxes***

As of November 1999 there were 12 PVC nest boxes hanging in the forests surrounding TRC. The nests are made from pieces of 14-inch (35 cm) or 12-inch (30 cm) diameter PVC pipe 1.5 m - 2.6 m long, lined with 2-inch x 2-inch (5 cm) diameter galvanized steel wire mesh to allow the birds to climb up and down the inside. Each box has two entrance holes placed at 90 degrees from each other near the top. The entrances range in size from 12 to 19 cm in diameter. Each box also has a small door near the bottom that allows the researchers to remove the eggs or chicks inside. In early September 1999 each nest was located and briefly observed to record adult activity. Starting 18 November 1999 each active nest was climbed once every 2 – 3 days. Nests that had no activity were climbed once every 7 days. Each time a nest was climbed the following was recorded: presence or absence of adults, number of eggs, number of chicks, chick weight, chick culmen length, chick tarsus length and chick wing cord length.

During the first month of life chicks that did not continue to gain weight at a rate of 5% per day were checked every day. If they showed weight loss, began to act lethargic and had an empty crop we would check the chick again in the late afternoon. If the birds had not improved by afternoon we would feed the chick, filling its crop with a commercially available diet specially formulated for young macaws made and donated by Harrison Bird Diets. The chick was then checked the following morning and afternoon and fed if the crop was empty and if it failed to show significant weight gain.

***Hand-raised macaws***

Since 1992 a total of 34 macaws that would have died of starvation have been hand-raised and released at TRC (Nycander et al 1995 and unpublished data, Table 1). Of these 6 were Blue-and-gold Macaws, 5 were Green-winged Macaws and 23 were Scarlet Macaws. The birds were raised without trying to isolate them from human contact (see Nycander et al 1995 for more details). Since their release some of the birds have continued to return to the buildings at TRC to look for food on an irregular basis. From 26 August – 6 September 1999 and 18 November 1999 – 16 March 2000 observers recorded the date, time, tail condition, band number and species for any macaw that flew in and landed in the lodge buildings. To facilitate reading the small numbers off the metal bands the birds were often attracted closer and distracted by offering a banana. For each bird it was also recorded if they were accompanied by a potential mate.

## Results

***Palm tree persistence***

In September of 1999 there were a total of 12 of the original 42 trees still standing. All of the trees from 1991 had fallen as had most from 1992 and 1995. These trees that remained had been cut in a variety of different years including 1992, 95, 96, and 99 (Table 2). By the November 1999, the beginning of the nesting season, the one palm remaining from 1992 had fallen. While the formal "half-life" for these palms has not been calculated, the data from 1995 show that only 1 of 13 (8%) stood for 7 years while 4 of 11 (36%) of the palms remained standing for 4 years. This suggests that the average palm lasts less than 4 years.

***Palm use by macaws***

Blue-and-gold Macaws occupied 5 of the 11 dead palms that remained standing throughout the 1999 nesting season. None were occupied by Red-bellied Macaws. The palms macaws used had cavities that averaged 3.81 meters deep. Those that the macaws didn't use had cavities that averaged 5 cm deep. One tree that was not used was cut in 1996; despite the fact it was cut 3 years earlier, the exposed center was dry and hard and showed no signs of starting to rot. The other 5 palms that were not used by nesting macaws were cut in 1999. Three of them had no cavities at all but were wet and showed signs of active rotting. The other two unused palms had small cavities in the top but these were only 11 and 15 cm deep..

***Blue-and-gold Macaw nesting success***

In one nest two chicks hatched but then disappeared about 1 month later, probably taken by a predator. Another nest, in a palm cut in 1999, was less than 3 ft. deep (90 cm) and over the course of the season the bottom continued to rot making the hole deeper and deeper. Unfortunately, within a few days of hatching the bottom of the nest dropped out presumably killing the new chicks. In a third nest, the first clutch of eggs disappeared before hatching but the pair quickly re-laid. The two eggs from this clutch both hatched. The older chick became much larger than its younger sibling and the younger bird died within about 16 days of hatching. The older chick survived to fledge. At another nest the same pattern was repeated, the younger chick died and the older survived to fledge. In the 5th and final nest, only one egg hatched and this chick went on to fledge about 90 days later. In summary, five nests started, three failed (at one of these the adults re-laid) and the three nests fledged one chick each (Table 3).

***Scarlet Macaw nesting success***

Twelve artificial nest boxes and 4 natural tree cavities known to contain nests in previous years were monitored in the 1999-2000 season. One of the natural cavities showed no activity. Green-winged Macaws nested in two of the natural tree cavities and both nests failed. The fourth cavity was occupied in September by Scarlet Macaws, but by the beginning of monitoring in November it was occupied by Cuvier's (or White-throated) Toucans (*Ramphastos cuvieri*). The pair of macaws continued to remain in the area throughout the nesting season but never took possession of the cavity and laid eggs. This nest had an extremely narrow entrance and the macaws had difficulty entering and exiting.

Of the 12 nest boxes, 11 were defended by pairs of macaws at some point between September and December 1999. Pairs laid eggs in 9 different nests for a combined total of 30 eggs. Of these 30 eggs, 10 were depredated or cracked, 10 did not hatch, and 10 hatched (Table 4). Of the 10 chicks that hatched 5 starved (or would have without intervention see "Helping younger chicks" below), 2 died for reasons other than starvation, 1 was transplanted to another nest (unpublished data) and 3 fledged. The estimated ages at fledging for these 3 chicks were 87, 90, 91.5 days.

Of the 5 chicks that starved, one was the first hatched chick of a pair where the female was one of the hand-raised macaws (see Nesting of hand-raised macaws below). The youngest two chicks in a nest of four chicks starved to death at ages 3 and 6.5 days of age. In this same nest the second oldest chick was pulled from the nest at age 17 days and fed overnight after it began to loose weight and strength. This chick would have died without intervention. Similarly at a different nest the second chick was fed two days in a row at age 4 and 5 days (Table 5). Both chicks that were fed were not fed again. As a result of these few feedings both of these nests fledged two chicks.

***Survival and breeding of hand-raised macaws***

From 26 August – 6 September 1999 and 18 November – 16 March a total of 11 of the 34 hand-raised macaws were resighted (Table 1). Of these 2 were Green-winged Macaws and 9 were Scarlets. This indicates that at least 40% of the released Green-wings remain alive (2 of 5 released) and at least 40% (9 of 23) of the Scarlets remain alive. It is certain that not all individuals that are still alive are regularly returning to the buildings at TRC. The evidenced supporting this is that two individuals that were known to be breeding within 1 km of TRC were only seen at the lodge once during the entire period of September – March. Of the 11 that were resighted 7 were mated with wild birds. Three of these pairs, all Scarlets, were found nesting in artificial nest boxes. A 7 year old and its mate defended a nest box for the entire season but never laid eggs. A 6 year old laid two eggs but the eggs cracked shortly before hatching and well developed embryos were visible. A 7 year old

Scarlet laid 2 eggs, both of which hatched. The first chick was found dead within one week of hatching with an empty crop and may have died of starvation. The second chick hatched and fledged at about 90 days of age.

A total of 6 Blue-and-gold Macaws were hand-raised and released between 1992 and 1994. Of these, none have been seen during 1999-2000. Anecdotal accounts and personal communications from guides and researchers suggest that all these birds began to fly with wild birds at an early age and broke their dependence on the food from people at a young age. As a result it is thought that the disappearance of these birds is due to a difference in their behavior not a difference in their survival rates. Unfortunately with no way to know if the birds have survived, this theory cannot be tested.

## Discussion

### *Palm swamp nesting*

The data presented here are the first that allow calculation of the average useable period for dead palms and the average number of chicks fledged per palm. While the sample sizes are still small, they do provide a general idea of the effectiveness of topping palms to encourage macaw nesting. The data suggest that the average palm lasts for less than 4 years before it rots and falls over. Of the palms cut in 1999, 1 of 6 (17%) was useable in the 1999-2000 nesting season. Similarly of 10 palms cut in 1992, only 2 (20%) were useable in that first year (Nycander et al 1995). Combining these data from 1992 and 1999 only 3 of 16 (19%) of palms are useable during the first season after they are cut. As a result, most palms are available to nesting macaws for a little less than three nesting seasons. The nesting data reported here show that three chicks were fledged out of the five palms used by macaws (0.6 chicks per nest). Data from 1992 show that one of the two nests used by macaws fledged a chick (Nycander et al 1995). Combining these data shows that 4 chicks fledged from the 6 nests that were initiated (0.67 chicks per nest). This is similar to the data reported from natural nests where 10 chicks fledged from a total of 14 nests (0.71 chicks per nest Nycander et al. 1995). These data suggest that during the time a palm is useable (an average of about 3 nesting seasons) a total of about two chicks will be fledged ([0.67 chicks per nest] x [3 nesting seasons]=2.0 chicks per palm over the useful life of the palm). Of course the palm survival estimate and nest success are based on a small sample sizes so the final figure of 2 chicks per palm should be considered only preliminary. In addition, the researchers that worked from 1992-1996 habitually cut holes in the side of the palms to allow them to remove the chicks for measuring. I suspect that this habit hastened the fall of the palms. If this is the case it will mean that palms may last significantly longer than the 4 years suggested here. Future monitoring in the swamp will help clarify these issues and allow us to refine the estimate presented here.

In an effort to find a more durable nesting substrate for the Blue-and-gold macaws I hung a nest box in the palm swamp in March of 1999. The nest box is made from a 2.5 meter long piece of 12-inch diameter PVC pipe. The 12-inch diameter matches almost exactly the diameter of the palm cavities the birds are using naturally. It has a metal bottom but no top, in order to imitate the open-topped palm cavities that the birds use naturally. It is hung from a live palm at a height of about 13 meters. An additional 2 or 3 such boxes will be hung in the swamp this July in an effort to test if this sort of box is a suitable alternative to natural palms. Despite the fact that the box mimics the natural characteristics of the palm nests the macaws already use, there is some concern that the birds will not use this design. This is because the Blue-and-golds in southeastern Peru do not nest in live palms even when they contain good cavities (Eduardo Nycander personal communication). As a result, these boxes, hung from live palms, may not induce the birds to nest. Despite this concern, hanging these boxes is our first step towards designing a more durable artificial alternative to dead palms. If the boxes fail to attract macaws in the 2000-2001 breeding season more complex freestanding structures will be erected in future years.

***Green-winged Macaw Nesting***

In the 1999-2000 nesting season Green-winged Macaws nested in two natural cavities in the vicinity of TRC and both nests failed. These macaws have never nested in the PVC nest boxes that are used by Scarlet Macaws. In July 2000, 6 new nest boxes will be hung in an effort to develop an artificial nest useable by Green-winged Macaws. Three nests will be exactly the same as those used by Scarlet Macaws except they will be made from PVC pipes with an inside diameter of 16-inches (40.6 cm) as opposed to the 12-inch and 14-inch currently used by the Scarlets. The other three boxes will be made from 1.66m long pieces of 14-inch diameter PVC pipe and will have the entrance hole cut in the top. These boxes will then be hung horizontally under one of the large horizontal branches that are found so commonly on the emergent *Dipteryx* trees in the Tambopata region. This will be done to simulate the naturally horizontal nest sites that these birds frequently use.

***Scarlet macaw nesting***

The data reported here give the first indication of the success rates for nests in PVC nest boxes. Nine pairs laid eggs and of these only 3 fledged young. Without intervention each of these would have fledged only 1 chick. This yields a total of 0.3 young per pair that laid eggs. Data from natural nests shows that of 14 nests where eggs were laid, a total of 9 fledged at least one chick (64%, Nycander et al. 1995). The finding of lower fledging rates in nest boxes was unexpected. The lower success in boxes is unusual since the incidence of parasites, especially bot flies, was reportedly high in natural nests but during the 1999-2000 season two chicks had a total of one bot fly each. A detailed comparison of the mortality in natural and artificial nests shows that in artificial nests egg destruction was higher, hatching success lower and starvation rates by younger chicks were higher (Table 6, 7, sample sizes too small for statistical testing). The other forms of chick death seemed to be similar between the two types of nest substrates. The low hatch rate in nest boxes is apparently a combination of two major factors. Seven of the 10 eggs that didn't hatch were laid as two successive clutches by the same pair. These eggs were apparently infertile or died at a young age. If the eggs from this one pair are removed, the hatching success shoots up to 43%, similar to the 48% reported for the wild nests. The apparently high rate of starvation in nest boxes is due to the fact that 3 of 4 chicks starved in a single nest that hatched 4 chicks. The one major factor that seemed to hold across the artificial nests was the high incidence of egg cracking in the boxes (combined with depredation in Table 7). The reasons for this high rate of egg cracking are currently unknown.

***Starvation of younger chicks***

At the beginning of the paper two theories were presented as to why the younger chicks in nests starve. The first was that the parents could not collect enough food to meet the nutritional demands of more than one chick. The second was that sibling rivalry or parental behavior results in an inequitable distribution of food that caused the younger chicks to starve. The chicks that starved were all less than one week old. Similarly one additional chick would have starved at age 4-7 days if it had not been fed. The one other chick that was fed was showing clear signs of starvation at 17 days of age. The chicks at one week of age weigh about 10% - 15% of their final fledging weight. Even at 17 days the birds still weigh only about 25% - 30% of fledging weight. After the feedings at 7 and 17 days, neither chick needed to be fed by the researchers again. The total nutritional demands of chicks are much lower during the first 1-3 weeks than they are as they approach fledging. The fact that the parents could raise two chicks successfully to fledging after the few early feedings shows that the parents are capable of collecting enough food to raise more than just one chick. If this trend continues to hold up in future nesting seasons it will show that parents are capable of finding enough food to raise more than one young, so supplemental feeding of adults or planting of additional food sources may not be the ideal method to reduce starvation of younger chicks. Future work at TRC will continue to document the timing of starvation and attempt to determine why the parents do not feed younger chicks.

This work shows that feeding chicks and leaving them in the nest is a viable way to save younger chicks from starvation. The two chicks that were saved this past season were fed only once each relatively early in life. This indicates that only a small amount of feeding at critical periods may be needed to allow the younger chicks to survive. In future field seasons I will continue to document the ages at which the chicks need to be fed in order to define the critical periods when monitoring and feeding needs to be concentrated. At nests with more than 2 chicks, I will feed all younger chicks and see how many chicks can be fledged from a single nest using this technique.

***Hand-raised macaws***

The data reported here are the first that document the successful integration of hand-raised macaws into a wild population. None of these birds are still receiving a significant portion of their daily nutrition from the lodge. All are feeding almost exclusively on wild food sources in the surrounding forest. Most of the birds that return to the lodge have formed pairs. In addition the data presented here document for the first time breeding in the wild by a captive raised and released macaw. This shows that hand-raised macaws can learn to forage and avoid predators without the help of their parents. It also shows that hand-raised and imprinted macaws can fully integrate into wild populations. The resightings show that 78% of the birds survived the first year (Nycander et al 1995) and that at least 40% of the macaws survived for 5 – 7 years after reintroduction (this study). The high rates of survival reported here shows that releasing hand-raised birds is a viable option in areas distant from hostile human populations.

The survival rates reported here are relatively high in comparison to those found in other releases of psittacids. For example only 1 of 3 hand-raised Puerto Rican Parrots (*Amazona vittata*) survived the first week after release (Meyers et al. 1996). In Arizona, none of the 23 captive-raised Thick-billed Parrots (*Rhynchopsitta pachyrhyncha*) survived the first 2 months (Snyder et al. 1994). The only parrot release that reported similar survival rates is for Yellow-shouldered Amazons (*Amazona barbadensis*) on Isla Margarita, Venezuela where 10 of 12 (83%) survived the first year (Sans and Grajal 1998).

The complete lack of resightings of Blue-and-gold Macaws coupled with their propensity to wander from the lodge and associate with wild birds from a younger age suggests that these birds may have integrated more quickly into the wild population. If this is true, it suggests that the hand-raising may have a much smaller impact on the behavior of this species than on Green-winged and Scarlet Macaws. If this is true, hand-raising may be a viable release strategy for this species, even in areas close to human populations.

## Conclusions

The data presented here show that survival of the hand-raised macaws has been very high and provide the first documented accounts of breeding by hand-raised macaws in the wild. Despite the fact that these released macaws are imprinted on humans they have completely integrated in to the wild population and are now reproducing. This indicates that the hand-raising techniques employed in the early 1990's (Nycander et al. 1995) were successful. As a result, similar techniques could be used to reintroduce macaws into areas where there are no hostile human populations. The disappearance of the hand-raised Blue-and-gold Macaw suggests that this species may be less prone to imprinting than Scarlet and Green-winged Macaws, but this cannot be critically tested.

The data suggest that dead palms may be useable by Blue-and-gold Macaws for as few as three nesting seasons. The nest success rate of 0.67 nests per nesting attempt suggests that during the three seasons a palm is useful a total of about 2 chicks would naturally fledge. These estimates are very preliminary, but show that a more durable nesting substrate is desirable for long-term management of palm-nesting macaws. Towards this end new PVC nest boxes are being erected in the TRC palm swamp and these boxes will be monitored in the coming years.

The PVC nest boxes designed and hung in the early 1990's have proven to be acceptable to Scarlet Macaws and very durable. In comparison to natural nests, the boxes seem to have slightly lower fledging success. The reason for this is unclear, but may be due in part to the high incidence of egg cracking in the nests during the 1999-2000 season. Data from these nest boxes also provided valuable information on the timing of chick starvation. The chicks all starved at very young ages suggesting that it is unequal distribution of food and not a total lack of food that is causing the chicks to die. In future seasons the work at Tambopata Research Center will continue with the goals of better documenting the patterns discussed here and finding new ways to increase the reproductive output of Blue-and-gold, Scarlet and Green-winged Macaws.

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Table 1: Survival of hand-raised macaws released from Tambopata Research Center, Peru. Data for Scarlet (*Ara macao*) and Green-winged Macaws (*Ara chloroptera*) combined.

| Year released | # released | Seen March '94* | Seen '99-'00 |
|---|---|---|---|
| 1992 | 1 | 0 | 0 |
| 1993 | 17 | 14 | 7 |
| 1994 | 8 | N/A | 4 |
| 1995 | 2 | N/A | 0 |
| Total | 28 | 14 | 11 |

* Data from Nycander et al. 1995

Table 2: Persistence of aguaje palms (*Mauritia flexuosa*) after cutting in a palm swamp near Tambopata Research Center, Peru.

| Year Cut | Number | Number remaining Sept. '99 | April '00 |
|---|---|---|---|
| 1991 | 10 | 0 | 0 |
| 1992 | 13 | 1 | 0 |
| 1995 | 11 | 4 | 4 |
| 1996 | 1 | 1 | 1 |
| 1999 | 6 | 6 | 6 |
| Total | 42 | 12 | 11 |
| | | 28% | 26% |

Table 3: Nesting success for Blue-and-gold Macaws (*Ara ararauna*) in a small palm swamp near Tambopata Research Center, Peru.

| | 1992 | 2000 |
|---|---|---|
| Nests initiated | 2 | 5 |
| Eggs | 5 | 13 |
| depredated | 0 | 5 |
| didn't hatch | 1 | 2 |
| Chicks | 4 | 8 |
| starved | 2 | 2 |
| depredated | 1 | 3 |
| fledged | 1 | 3 |

Table 4: Nest success for Scarlet Macaws (*Ara macao*) nesting in PVC nest boxes near Tambopata Research Center, Peru.

| | # |
|---|---|
| Available boxes | 12 |
| Used | 10 |
| Eggs | 30 |
| depredated | 10 |
| didn't hatch | 10 |
| Chicks | 10 |
| starved | 4* |
| other death | 2 |
| fledged | 3* |

Table 5: Age at starvation for Scarlet Macaw chicks nesting near Tambopata Research Center, Peru. Birds that were fed would have most likely starved if not fed by the researchers (see text).

| Age | # of Second Chicks | Starved | Fed |
|---|---|---|---|
| < 7 days | 4 | 2 | 1 |
| 7-21 days | 2 | 0 | 1 |
| >21 days | 2 | 0 | 0 |
| **Total** | **8** | **2** | **2** |

Table 6: Comparison of hatching success for Scarlet Macaw eggs in natural and artificial nests in southeastern Peru. Data from artificial nests comes from Tambopata Research Center. Data from natural nests includes data from Manu National Park and Tambopata Research Center.

| | Artificial | | Natural* | |
|---|---|---|---|---|
| Nests | 10 | | 8 | |
| Eggs | 30 | | 19 | |
| depredated | 10 | 33% | 4 | 21% |
| didn't hatch | 10 | 33% | 4 | 21% |
| hatched | 10 | 33% | 11 | 58% |

* Data from Nycander et al. 1995

Table 7: Comparison of fledging success for Scarlet Macaw eggs in natural and artificial nests in southeastern Peru. Data from artificial nests comes from Tambopata Research Center. Data from natural nests includes data from Manu National Park and Tambopata Research Center.

| | Artificial | | Natural[1] | |
|---|---|---|---|---|
| Nests | 10 | | 14 | |
| Chicks | 9 | | 21 | |
| starved | 4[2] | 44% | 4 | 19% |
| other death | 2 | 22% | 7 | 33% |
| fledged | 3[3] | 33% | 10 | 48% |

1. Data for wild nests from Nycander et al 1995
2. The two chicks that were starving but were fed and eventually fledged are included in the list of chicks that died of starvation.
3. This does not include the 2 chicks that were fed and later went on to fledge.