

ZOO BIOLOGY

Contents

VOLUME 30, NUMBER 3, 2011

RESEARCH ARTICLES

- 241 **Ultrasonographic Monitoring of Fetal development in Unrestrained Bonobos (*Pan paniscus*) at the Milwaukee County Zoo**
Barbara Drews, Leanne M. Harmann, Leann L. Beehler, Barbara Bell, Reinhard F. Drews, and Thomas B. Hildebrandt
- 254 **Radiographic Diagnosis of Metabolic Bone Disease in Captive Bred Mountain Chicken Frogs (*Leptodactylus fallax*)**
Jay D. King, Michael C. Muhlbauer, and Arlington James
- 260 **Age Class Differences in the Feeding Behavior of Captive Japanese Macaques (*Macaca fuscata*) in the Forested and Nonvegetated Enclosure Groups**
M. Firoj Jaman and Michael A. Huffman

BRIEF REPORTS

- 275 **Ovarian Cycle Approach by Rectal Temperature and Fecal Progesterone in a Female Killer Whale, *Orcinus orca***
Satoshi Kusuda, Yuka Kakizoe, Koji Kanda, Tomoko Sengoku, Yohei Fukumoto, Itsuki Adachi, Yoko Watanabe, and Osamu Doi
- 286 **Food Habits of *Rhinopithecus bieti* as Assessed by Fecal Analysis at Mt. Longma, Southwest China**
Xue-You Li, Shi-Jian Yang, and Yang Yang
- 298 **Serum Concentrations of Insulin-Like Growth Factor-I and Insulin-Like Growth Factor Binding Protein-2 and -3 in Eight Hoofstock Species**
Kristen E. Govoni, Danielle Goodman, Rebecca M. Maclure, Linda M. Penfold, and Steven A. Zinn
- 308 **Proximate Composition of Milk From Free-Ranging Mountain Gorillas (*Gorilla beringei beringei*)**
Christopher A. Whittier, Lauren A. Milligan, Felicia B. Nutter, Michael R. Cranfield, and Michael L. Power

HUSBANDRY REPORTS

- 318 **Development of Husbandry Practices for the Captive Breeding of Key Largo Woodrats (*Neotoma floridana smalli*)**
Christina A. Alligood, Andre J. Daneault, Robert C. Carlson, Thomas Dillenbeck, Catharine J. Wheaton, and Anne Savage
- 238 **First Captive Breeding of the Imperial Parrot (*Amazona imperialis*)**
Paul R. Reillo, Stephen Durand, and Minchinton Burton

TECHNICAL REPORTS

- 342 **An Alternate and Reversible Method for Flight Restraint of Cranes**
Sen Lin Zhang, Shu Hui Yang, Bing Li, Yan Chun Xu, Jian Hua Ma, Jian Feng Xu, and Xian Guang Zhang
- 349 **Effect of Feed Type and Sex on Digestibility and Feed Efficiency Utilization in Black Spiny-Tailed Iguana (*Ctenosaura pectinata*)**
P. Rueda-Zozaya, G.D. Mendoza, M.M. Crosby, G. González, and V.H. Reynoso

355 ANNOUNCEMENTS

356 FORTHCOMING

Volume 30, Issue 3, was mailed the week of June 6, 2011

ON THE COVER: The first imperial parrot (*Amazona imperialis*) hatched and raised in captivity was fully developed within 12 weeks. The imperial is a vital flagship for oceanic rainforest conservation, and chronicling the neonatal development helps illuminate the natural history of this enigmatic species. See related article by Reillo et al., pages 328–341.

ONLINE SUBMISSION AND PEER REVIEW

<http://mc.manuscriptcentral.com/zoo>

Published in affiliation with the Association of Zoos and Aquariums

INDEXED BY
MEDLINE!

ZOO BIOLOGY

• VOLUME 30 • ISSUE 3 • MAY/JUNE 2011

VOLUME 30 • ISSUE 3 • MAY/JUNE 2011

ZOO BIOLOGY

PAGES 241–359

WILEY-BLACKWELL



DAN WHARTON

Executive Editor

ASSOCIATION
OF ZOOS &
AQUARIUMS

WILEY-BLACKWELL

HUSBANDRY REPORTS

First Captive Breeding of the Imperial Parrot (*Amazona imperialis*)

Paul R. Reillo,^{1*} Stephen Durand,² and Minchinton Burton²

¹Rare Species Conservatory Foundation, Loxahatchee Groves, Florida

²Forestry, Wildlife and Parks Division, Roseau, Dominica

We describe the rearing and development of the first imperial parrot (*Amazona imperialis*) hatched and raised in captivity. A single egg was hen-incubated for 28 days, and the chick was parent-fed for ~14 days, after which it was removed for hand-rearing. Similar to wild, parent-reared imperial nestlings, the chick developed fully within 12 weeks, weaning at 540 g body weight. Endangered and endemic to Dominica, the imperial is a vital flagship for oceanic rainforest conservation. Chronicling the neonatal development of *A. imperialis* helps illuminate the natural history of this enigmatic species, whose secretive nesting habits and low population density have frustrated a detailed understanding of its ecology and reproduction. Zoo Biol 30:328–341, 2011. © 2010 Wiley-Liss, Inc.

Keywords: Dominica; flagship species; parrot conservation; captive breeding

INTRODUCTION

The imperial parrot, or sisserou (*Amazona imperialis*), Dominica's national bird [James et al., 2005], is the largest of the Amazon parrots [Forshaw, 1989]. Revered since Columbus's time [Lowe, 1984] and renown for its pivotal role as an iconic ambassador for the Nature Island's broad biodiversity protection efforts [Wiley et al., 2004], the imperial is elusive to ornithologists and its reproductive ecology is poorly understood [Collar et al., 1992; Snyder et al., 2000; Reillo and Durand, 2008]. Comprehensive field-based research and conservation efforts over

Grant sponsor: Batchelor Foundation.

*Correspondence to: Paul R. Reillo, RSCF, 1222 "E" Road, Loxahatchee Groves, FL 33470.

E-mail: paulreillo@rarespecies.org

Received 30 August 2010; Revised 5 November 2010; Accepted 18 November 2010

DOI 10.1002/zoo.20374

Published online 22 December 2010 in Wiley Online Library (wileyonlinelibrary.com).

the past 30 years have helped elucidate the species' distribution, habitat use, foraging and nesting behaviors and population structure [Reillo and Durand, 2008], and have enabled the species to rebound from the brink of extinction following Hurricane David in 1979 to nearly its pre-hurricane range and density [Reillo, 2001; Wiley et al., 2004]. Still, as a sparsely distributed, old forest-dependent psittacine endemic to a single island in the Atlantic hurricane zone, its status remains endangered, with a population of less than 350 birds [Birdlife International, 2008; Reillo and Durand, 2008].

Distributed at less than two birds per 1,000 ha across mountainous, oceanic rainforest, *A. imperialis* is a cryptic species with secretive nesting behaviors [Wiley et al., 2004]. Reproduction in the wild has been documented using a variety of monitoring techniques [Reillo and Durand, 2008], but intracavity inspection of the species' camouflaged nest sites has proven difficult. Until now, a detailed accounting of egg-laying and chick development has been lacking. In this study, we describe the first captive breeding of *A. imperialis*, and document chick growth and development from hatching through fledging.

METHODS AND RESULTS

The only known captive imperial parrots (Fig. 1), a pair, are housed at the Parrot Conservation and Research Centre (PCRC) at the Botanical Gardens, Roseau, Dominica, maintained by Dominica's Forestry, Wildlife and Parks Division. The male was acquired as an injured nestling (fractured upper mandible) in 1996 near the Heights of Salisbury and the female was rescued in 2000 as a premature fledgling from the Syndicate Estate area within the Morne Diablotin National Park [Nikolopoulos, 2000]. The pair is housed in a large flight cage ($\sim 13\text{ m} \times 7\text{ m} \times 3.5\text{ m}$) shielded from public view and maintained on a diverse diet comprising, by volume, one-third commercial parrot-seed mix (Parrot Supreme, Higgins Group Corp., Miami, FL) and pellets (Higgins Vita Krunch or Zupreem Fruit Blend) and two-thirds seasonal fruits and vegetables (e.g. bananas, citrus, greens, corn, apples, carrots, squash, mango, guava, and papaya). The birds are fully flighted, have experienced no health issues requiring treatment, and are handled only when evacuated from their enclosure before tropical storms. Mesh-lined, wooden nest boxes ($0.5\text{ m} \times 0.5\text{ m} \times 1\text{ m}$) with 0.1 m-deep pine shavings are provided for nesting.



Fig. 1. *Amazona imperialis* breeding pair at Parrot Conservation and Research Centre, Roseau, Dominica. Female (l), male (r).

The pair has been bonded since 2002, and each year since 2005 has exhibited intense courtship and nest-box interest from March through April. The first reproduction attempt was April 13–18, 2006, when two eggs were produced (44.4 mm \times 35.5 mm; 44.2 mm \times 34.9 mm; Fig. 2). The hen incubated the eggs for 3 weeks, after which they were candled and proved to be infertile. Infertile, single-egg clutches were laid in 2007 and 2008.

Unlike previous years, the aviary was completely shielded from public view before the 2010 nesting season, and in February, the pair commenced strong pair-bonding and courtship behaviors, including reciprocal feeding, frequent copulations, and nest-box defense. A single egg was laid on April 7 and confirmed to be fertile by candling on April 12. For the next month, aviary staff minimized contact time with the birds and a single keeper attended to the animals once each morning. The female imperial was protective of the nest and incubated the egg for 28 days, and the male visited and fed the female in the nest box. A single chick hatched on May 5, and its begging calls were clearly audible for the next week. On May 11, Forestry Division staff quickly inspected the nest box and photographed an apparently healthy ~100 g chick (Fig. 3), which appeared pink, plump, and active. The parents immediately resumed care of the chick after the inspection.

During the next 10 days, chick vocalizations gradually decreased, although the parents' behaviors and aviary-maintenance routines were unchanged. Photographs taken on May 21 revealed an emaciated, dehydrated chick with numerous insect



Fig. 2. First captive-laid *Amazona imperialis* eggs at PCRC, May 2006.

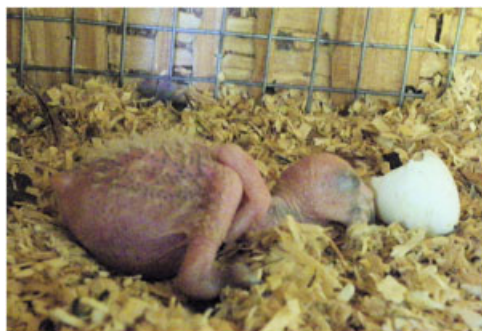


Fig. 3. *Amazona imperialis* chick at 6 days of age, in the nest box.



Fig. 4. Dehydrated 16-day-old *Amazona imperialis* chick in the nest box.

bites on its head and back (Fig. 4); likely, it had not been fed for several days. The chick appeared to be failing and had difficulty raising its head. Forestry Division staff removed the chick for emergency care and hand-reared on May 23 at 18 days of age. Its weight at the time of removal was 152 g.

The chick was immediately brooded at 33°C and near-saturation humidity in a custom-made, forced-air, light-shielded avian intensive care unit in an air-conditioned room at the PCRC, adjacent to the parents' enclosure. Around-the-clock emergency care was initiated, commencing with syringe-feeding a diluted, commercial parrot hand-feeding formula (Kaytee Exact). Within 2 days, the chick's crop ceased emptying, and dehydration persisted.

Droppings with abnormal, yellow/brown color, pasty consistency, and turpene odor indicated gut impaction by pine nest-box shavings, likely ingested during several days of starvation in the nest. Mineral oil and psyllium–husk solutions, delivered orally (2–4 ml), in combination with several 2–3 ml of lactated Ringers enemas, emptied the crop and gastrointestinal tract over a 12-hr period on May 26. Gut motility with Kaytee Exact formula remained poor, but stools returned to normal appearance (formed, greenish-tan in color, clear urates). Subcutaneous lactated Ringers, antibiotics (enrofloxacin, cephadroxil, 20 mg/kg body weight, PO, SID), and oral electrolytes (Pedialyte, Abbott Laboratories, Columbus, OH) were administered as various, custom hand-feeding formulas were tried in an effort to obtain normal hydration and gut motility.

By May 27, the chick was stabilized with a regimen of 12 ml Zupreem monkey-biscuit formula (six boiled biscuits mixed with Pedialyte electrolyte solution and Gerber's papaya baby food puree) and 2 ml subcutaneous lactated Ringers solution delivered every 2.5 hr. By May 28, the chick was beginning to gain weight (174 g, crop empty), but remained insufficiently hydrated on formula alone, requiring 2–3 ml subcutaneous lactated Ringers every 4–6 hr.

With limited avian diagnostic and support resources available locally, the decision was made to evacuate the chick to the Rare Species Conservatory Foundation (RSCF) facilities in Florida for recovery and rearing. CITES import and export documents were coordinated between Dominica's Ministry of Agriculture and the Environment, Veterinary Services Department and Environmental Coordinating Unit, the US Department of Agriculture, US Fish and Wildlife Service and RSCF. At 1530 hr on May 29, after a 2.5-hr drive from Roseau to Melville Hall,

the chick and the senior author were flown by Lear-35 air ambulance from Melville Hall Airport non-stop to Palm Beach International Airport, arriving at RSCF's facility, under USDA escort, at 1900 hr. The chick's weight at departure was 200 g, fully hydrated (Fig. 5), and the plane's equipment permitted proper brooding and hand-feeding en route. Despite 7 hr point-to-point travel time and significant stress during the ground-transport legs, the chick arrived in good condition.

On arrival, the chick entered a 33-day, USDA-sanctioned, on-site quarantine, requiring two rounds of negative avian influenza and Newcastle's tests, 2 weeks apart. During quarantine, the chick was housed in a modified Humidaire brooder within a dedicated building with staff living quarters; afterward, the chick was transferred to RSCF's parrot-rearing nursery.

Early cultures revealed heavy *Escherichia coli* and *Candida* infections, necessitating treatment with enrofloxacin and fluconazole (20 mg/kg body weight PO, SID) during the next 10 days. Cultures were repeated every 2–3 weeks through weaning, with appropriate antibiotic/antifungal treatment as necessary. Ambient laboratory conditions and the use of a custom, saturation-humidity brooder quickly facilitated normal hydration without further subcutaneous fluid injection.

Daily, empty-crop weights were recorded at 0500–0600 hr and periodically throughout the day through June 24 and once per day afterward (Fig. 6). The chick was photographed daily to chart development, and daily changes in behavior were



Fig. 5. *Amazona imperialis* chick at 24 days, just before evacuation to Florida.

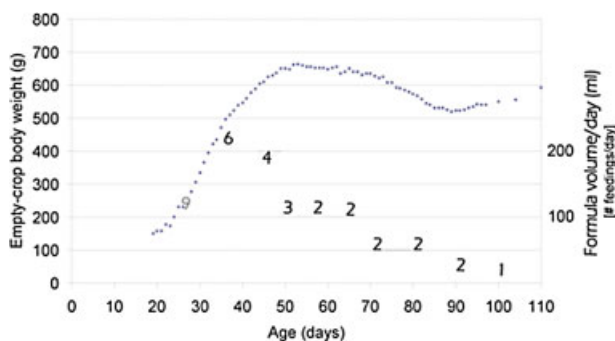


Fig. 6. *Amazona imperialis* chick growth (scatterplot) and volume of formula consumed (# of feedings) per day as functions of age.

noted. Before weaning, the chick was reared exclusively on a Zupreem monkey-biscuit-based formula, comprising blended monkey biscuit, papaya baby food puree, canola oil (6 ml/l of formula), and liquid multivitamins (Mega-vita-liquid, Puritan's Pride product #47, www.puritan.com). Several efforts to convert the chick to standardized, commercial hand-feeding formulas caused immediate crop stasis; hence, further attempts were abandoned. The chick was syringe-fed whenever the crop was empty, filling the crop to a full, rounded condition at each feeding. Loose formula was delivered before Day 30, after which thickness was increased to produce a smooth, pudding-like consistency. All contact surfaces were sanitized at each feeding. Feeding frequency and formula volume varied with age and weight (Fig. 6), with the greatest volume (210 ml) delivered at 36 days of age (June 10, 30–35 ml per feeding, six bouts per day). Hand-feeding frequency and formula volume began to decline just as maximum body weight was achieved (663 g at 53 days of age), after which feeding volume and frequency steadily decreased through the weaning period (average crop-empty weight = 540 g). Coordination and mobility increased gradually during the 60-day feathering period and rapidly after flight feathers were fully developed (Day 78). Sex was determined to be male via PCR test (G. Amato, American Museum of Natural History, NY) on feathers submitted at 14 weeks of age.

In the following, we chronicle rearing methods and the chick's development by age in days (date)

Day 36 (June 10)

The under parts of the body are covered with a dark, fluffy down, and the wing primaries and coverts are lengthening. Eyes have been open for ~10 days, and the animal can focus and orient to objects and movement. Irises are dark brown-grey in color. Begging vocalizations have decreased during the past 10 days, but the chick begs following most feedings for ~5 min. Aside from gentle stimulation of the preen gland area and upper back, manipulation and grooming are rebuffed with sharp squawks and squirming. Before full visual acuity (Day 32), the animal was very light-sensitive and cowered in low light; the chick was brooded in full darkness until it positively oriented to light, and then the brooder window was gradually uncovered. The brooder window simulates a natural cavity opening and allows ambient room light to enter. The Humidaire brooder maintains saturation humidity, 30.5°C, and the chick rests on cotton towels atop a plastic-mat-lined, polycarbonate bin. The chick respires normally, and sleeps on its belly, standing only when disturbed or hungry. The chick appears to thrive in terms of activity, proportionality of body features, coordination, and overall size. It has become a challenge to feed unless very hungry, refusing the syringe or shaking food from its beak. Stools are greenish-tan in color and semi-solid, and urates are clear.

Day 43 (June 17)

The leading edges of the wing feathers are developing and the primaries are lengthening with the sheaths beginning to split (Fig. 7). Visual and auditory acuity are excellent, and the bird tracks fine movements and responds to very slight volume and pitch changes in environmental sounds. It cowers when exposed to ambient room light, but spends much of the daylight hours looking out of the brooder window. The bird sleeps intermittently during the day and immediately for an hour or more after feedings, but is otherwise upright, preening, investigating movements in the room, and walking about. It recognizes its caregiver by standing alert and facing forward

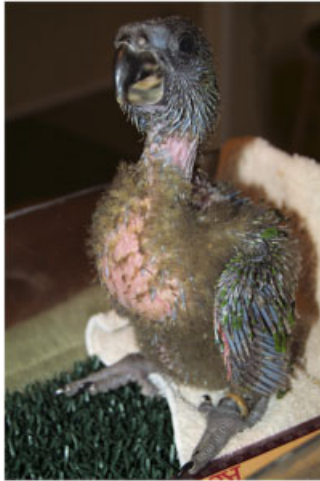


Fig. 7. Age 41 days.



Fig. 8. Age 49 days.

whenever he enters the room, and allows limited grooming, primarily along the lower back, beneath the crop, and on the nape, which are covered with quills. Vocalizations include soft whining and occasional cooing noises, although when startled the chick can emit loud barks and shrieks. It anxiously begs to be fed at first light; after sunset, the chick prepares for sleep immediately and exhibits no interest in food. Syringe-feeding is difficult, as the bird insists on tasting every drop of formula; five or more minutes are required to discharge 45 ml, during which time the formula cools and the chick becomes restless. The chick refuses formula below 40°C.

Day 50 (June 24)

Wing coverts, head and tail feathers are opening (Fig. 8). The chick's heavy body weight limits locomotion, but it is able to climb and grasp a perch. The chick is very aware of surroundings, and is sensitive to light, noise, and any motion in the

room. Unless the hand-feeding formula is smooth and viscous, at 42°C and delivered in slow, steady 2–3 ml increments, the chick rejects it with head-shaking. Exercise periods lasting ~20 min twice per day have been initiated to improve muscle tone and coordination. The chick ambulates on a textured mat in the laboratory (room conditions 27°C, 60% RH) and can climb small obstacles, but tires easily. It preens and stretches during exercise periods and begs when returned to the brooder (temperature 28.5°C, saturation humidity). The bird tolerates grooming and handling, and invites scratching on the nape and back, where large feather quills are opening. The bird elicits a strong feeding response only when stimulated by gently pinching the beak commissure. Similarly, nape grooming and tactile manipulation of the beak inspire movement, vocalizations, and exploration.

Day 56 (June 30)

Feather development is nearly complete, with only the tail and wing primaries still partially sheathed (Fig. 9). The full complement of colors is evident, even though the plumage is juvenile. The slimming process associated with weaning has commenced. The chick has begun wing-flapping. Copious fat deposits are still visible, and the chick appears immature compared with a fledged *A. imperialis*. Muscle tone is improving, and its grip and bite are strong. When startled, the bird emits very loud blasts and squawks, but most vocalizations are minor begging calls or whines and plaintive, cooing noises. The feeding response is entirely absent unless the chick is hungry, and 10–11 hr are required for full crop emptying and feeding solicitation to occur. The bird focuses its attention on slight movements in the room, has excellent low-light visual acuity, and alerts to sounds at high and low frequencies. The chick is gradually habituating to ambient environmental conditions, cowering less frequently. Routine choanal and cloacal cultures reveal normal gut flora.

Day 65 (July 9)

The bird has begun eating solid foods on its own, even though the flight feathers are not fully developed. All presented foods are investigated immediately, and the bird samples pellets, fruits, nuts, and vegetables. It drinks water from a bowl unprompted. The daytime schedule now has the first feeding at 0600–0630 hr, after



Fig. 9. Age 57 days.

which the bird is moved into a small wire cage, with perches, that receives ambient sunlight. The cage allows for safe climbing and wing-flapping but is sufficiently small to prevent self-injury. The bird remains in this enclosure from 0630 to 1700 hr and is visited frequently throughout the day and given two or three exercise periods, unbounded, during which time it tends to walk around the room and climb on any available structure. The second and final formula feeding of the day occurs between 1700 and 1730 hr, after which the bird is transferred to its nighttime brooder box, maintained at 26°C, for sleeping. The bird sleeps soundly between 1930 and 0530 hr, but also takes several short naps during the day. During exercise periods, the bird rarely vocalizes except for soft cooing noises, although it can emit a trumpet-like blast when startled. Attempts to socialize the bird with other Amazon juveniles (five *A. rhodocorytha*, aged 16–18 weeks) have failed—the bird retreats from other birds. Wing-flapping is increasing in frequency (3–4 times per day) and duration (4–5 seconds), and the primaries are now ~75% developed. Crop reduction associated with weaning is evident, with crop capacity ~15% less than 2 weeks ago.

Day 71 (July 15)

All feathers but the primaries are fully developed, with the primary sheaths at full length (Fig. 10). Head, nape, chest, and covert feathers are complete and tail feathers are at full length. The irises are beginning to change hue, toward a rusty-red. The bird resides in its wire enclosure full-time, covered at night, 1900–0630 hr. Wing flapping occurs for approximately 5 sec four to five times per day. Flapping can be stimulated by lifting and scratching under the wings. It samples many solid foods and can crack sunflower seeds. Hand-feeding bouts are prolonged, as the chick attempts to climb away even when the crop is empty (e.g. during the first feeding at 0630 hr). Feedings (0630 and 1700 hr) are accomplished by drizzling 3–5 ml of 42° formula over a 20-min period. The bird uses its beak to pick up unfamiliar, adult foods presented during exercise periods, and samples these when returned to its enclosure. Vocalizations are few, and comprise mostly cooing noises (which occur when investigating new places or foods) and sharp squawks or begging calls. The bird tires after 15-min exercise periods but preens, turns around on its perch without stumbling, balances on one foot, and periodically climbs from a high perch to the food bowl to eat. Solid foods comprise 10–15% of the total diet. Pellets, melon, apple, corn, pecans, grapes, and monkey biscuit are macerated, with small quantities consumed. The crop is now half the size of 2 weeks ago, and breast muscle



Fig. 10. Age 66 days.

development is noticeable. Socialization with other Amazon parrots is still difficult, as the imperial is timid around other birds, and cowers.

Day 78 (July 22)

The bird is experimenting with flight (1–3 m forays), even as the primaries are still developing (Fig. 11). Appetite for adult food is increasing, and the bird reluctantly accepts formula. Exercise periods last 20–30 min, during which time the bird climbs, flaps its wings, and investigates new spaces. Fear and aggression are expressed with clear, loud squawks, and the youngster attacks and bites caregivers if provoked. Aside from a few, brief, daytime naps, the bird is awake and active from 0630 to 1830 hr.

Day 86 (July 30)

The imperial's plumage is fully developed. The bird has been introduced to a shaded, outdoor enclosure (6 m × 2.5 m × 3 m) for exercise periods lasting up to 1 hr. The bird's take-off and acceleration skills are excellent, but landings are uncoordinated, with the bird tending to fly head-long into objects unless a caregiver intervenes. Eagerness for the only evening feeding is expressed with begging and beak-pumping solicitation, as the chick expends the day's complement of calories exercising. The imperial is now sharing a nursery with young Red-browed Amazons (*A. rhodocorytha*) housed in a separate enclosure, so that it can observe older birds' behavior and eating skills. The imperial's food bowls have been shifted higher in the cage to prompt investigation. Most food items are now sampled, with solid foods comprising ~30% of daily nutrition.

Day 93 (August 6)

The imperial resembles a wild fledgling and is in the process of weaning. The bird flies 10–20 m and lands easily, negotiating smaller spaces and outdoor enclosures nimbly. The bird spends 2.5–3 hr outdoors each morning, either with *A. rhodocorytha* juveniles (Fig. 12) or in a dedicated enclosure. All young birds are brought into the nursery by 1300 hr due to high summer temperatures, >35°C. The

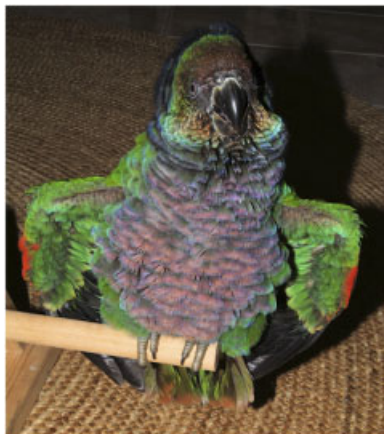


Fig. 11. Age 75 days.



Fig. 12. 93-day-old *Amazona imperialis* socialized with *Amazona rhodocorytha* fledgling.

imperial can fly on cue to a caregiver's hand, and no longer cowers when introduced to other parrots or humans. It is consuming 75% or more of its daily nutrition by eating on its own, preferring mango, corn, apple, melon, grapes, pellets and nuts. The bird can hold food with its foot while eating, but drops most items. The imperial begs for food and gulps it down in a single delivery. It sleeps from 2000 to 0530 hr.

Day 99 (August 12)

The imperial is nearly weaned, receiving one feeding at 1900 hr, which is preceded by loud, emphatic begging calls. It eagerly consumes mangoes, corn, apples, grapes, melon and nuts, cracks seeds and relishes light-colored pellets. It does not interact with its Red-browed Amazon companions, and fends off other birds near its food bowl. It mimics the vocalizations, movements, and food-eating techniques of its nursery companions, and now holds most food items with one foot while eating.

Day 106 (August 19)

Weaning is complete. The imperial has not been fed formula for 2 days, and is maintaining body weight. Sweet fruits, corn, and nuts are preferred, but pellets and seed comprise 20–25% of the consumed volume per day. Orange iris color is intensifying. The bird is housed outdoors 4–5 hr/day and indoors in its nursery cage during the heat of the day and overnight. Vocalizations of all kinds—whistles, coos, and squawks—have increased, and it begs loudly when a caregiver is spotted. It is a strong flyer and negotiates complex spaces, landing with ease. The bird is maintained in its own enclosure, but is housed adjacent to young *A. rhodocorytha* for companionship and socialization.

Day 118 (August 31)

The imperial is socialized from 0700 to 1600 hr in an outdoor enclosure with two young *A. rhodocorytha*, returning to its indoor cage at night, where it is housed separately. The imperial shares food bowls and perches, and the three birds interact peaceably with no signs of aggression from either species.

DISCUSSION AND CONCLUSIONS

With early, aggressive, medical intervention, and hand-rearing, the first captive-bred imperial parrot developed fully within 12 weeks, mirroring wild, parent-raised nestlings [Reillo et al., 2000; Forestry Wildlife and Parks Division, 2008]. Its thick, dark, juvenile down, accelerated feather development, and rapid weight gain are consistent with an *Amazona* species adapted to high elevations and cool, wet nesting conditions. Primary feathers were fully developed just as wing-flapping behavior commenced, and flying agility was achieved at 12–13 weeks, matching the age that wild fledglings depart the nest [Reillo et al., 2000]. Weaning onto adult foods was protracted as expected; wild imperial chicks follow their parents for up to 1 year post-fledging, and emphatically beg for food for many months [Durand and Zamore, 1996; Reillo and Durand, personal observation]. Weaning weight compares favorably with live weights from three wild, female *A. imperialis* (570 g fledgling, 509 g adult, 550 g adult, all collected 2000–2005).

The captive parents' first infertile, two-egg clutch in 2006 contrasts with field observations of single fledglings at several nests over a 10-year period [Reillo and Durand, 2008], but is consistent with two, wild siblings that fledged 3 weeks apart in 2008 [Forestry Wildlife and Parks Division, 2008] and a 1975 anecdotal field report of two chicks in a nest that subsequently failed [Forshaw, 1989]. These accounts support a typical clutch size of one, and rarely two, but precise determination of clutch size hinges upon differentiating the number of eggs laid from the number of successful fledglings. Fledglings are typically singletons observed either at the nest-cavity entrance before departure or post-fledging, following their parents. Nest-site observations and intracavity inspections are frustrated by the species' secretive nesting in epiphyte-cloaked cavities, typically located 25 m or higher in remote rainforest trees, primarily *Sloanea caribaea* and *Dacryodes excelsa* [Reillo et al., 2000; Wiley et al., 2004; Reillo and Durand, 2008].

Taken together, field and captive-breeding data reveal that *A. imperialis* exhibits the lowest reproductive potential of any extant *Amazona* species. Age at first reproduction in the wild is unknown, but egg fertility and chick hatching in captivity occurred at the age of 14 years for the male and 10 years for the female. The imperial's closest evolutionary congener, *A. guildingii* from the nearby island of St. Vincent [Russello and Amato, 2004], possesses similar physiology and ecology yet matures at 5 years, routinely produces clutches of two or three eggs, and occasionally may raise three chicks [Forshaw, 1989; Collar et al., 1992]. Although inferences based on one captive breeding pair are speculative, the imperial's slow sexual maturity, low recruitment rate, and reliance on undisturbed, primary, montane rainforest likely explain its slow population recovery following devastating Hurricane David (1979), which reduced the total population to perhaps 50 individuals [Gregoire, 1981; Evans, 1986, 1988]. Dominica's comprehensive land-conservation and forest-protection policies and legislation, including the January 2000 declaration of the Morne Diablotin National Park, the species stronghold, have enabled the imperial to sustain a population recovery for over 30 years [Reillo and Durand, 2008].

Dominica's longstanding, successful imperial conservation program has emphasized *in situ* conservation of wild parrot populations [Reillo, 2000, 2001; Wiley et al., 2004]. The imperial luckily escaped exploitation by the wild-bird trade

that decimated many parrot populations [Wright et al., 2001], and for decades has been afforded special protection by international and Dominican law [Collar et al., 1992; Wiley et al., 2004; James et al., 2005]. Effective, ongoing recovery strategies do not rely on captive breeding, and presently there is no justification for removing competent birds from the wild for such purpose. However, nonreleasable parrots at the PCRC on Dominica may afford the occasional opportunity to observe reproduction and nestling development in a controlled setting. The unprecedented captive breeding, evacuation and rearing efforts described here represent a fortuitous byproduct of imperial parrot conservation, helping to further elucidate this enigmatic species' natural history and ecology.

ACKNOWLEDGMENTS

For coordinating export/import permits and facilitating the chick's rescue, we are indebted to, in Dominica: Mr. Samuel Carrette, Permanent Secretary for Dominica's Ministry of Agriculture and the Environment; Mr. Lloyd Pascal of the Environmental Coordinating Unit; Reginald Thomas, DVM, at Veterinary Services and staff of the Forestry, Wildlife, and Parks Division; in the United States: to Dr. Herb Raffaele, Tim Van Norman, and Carlos Pages of the US Fish and Wildlife Service; Peter Merrill, DVM, Elizabeth Enciso, DVM, and Jose Luaces of the US Department of Agriculture; RSCF Curator Karen McGovern; Paul and Irina Fisher; Jim Hoene, Larry Leet, and Capts. Thomas Mahoney and Kenneth Cole of American Aviation; and Sandy and Jon Batchelor. For animal-care assistance on Dominica, we thank Lenice Bruno and Randolph Winston; in the United States, for veterinary care and avian advice, Susan Clubb, DVM, Howard Voren, and Charles Osterbrink; for PCR sex determination, Dr. George Amato. This work was partially funded by a grant to RSCF from the Batchelor Foundation, Miami, FL.

REFERENCES

- BirdLife International. 2008. *Amazona imperialis*. IUCN 2010, IUCN Red List of Threatened Species, Version 2010.2. Available from: www.iucnredlist.org.
- Collar NJ, Gonzaga LP, Krabbe N, Nieto AM, Naranjo LG, Parker III TA, Wege DC. 1992. Threatened birds of the Americas, the ICBP/IUCN red data book, 3rd ed., Part 2. Cambridge, UK: Smithsonian Institution Press and International Council for Bird Preservation. p 380–393.
- Durand S, Zamore MP. 1996. Dominica parrot project, progress report for the period July 1994 to September 1996. Roseau, Dominica: Forestry and Wildlife Division. p 4–19.
- Evans PGH. 1986. Dominica multiple land use project. *Ambio* 15:82–89.
- Evans PGH. 1988. The conservation status of the imperial and red-necked parrots on the island of Dominica, West Indies. International Council for Bird Preservation Study Report 27, Cambridge, UK. p 37.
- Forestry Wildlife and Parks Division. 2008. New discovery by Dominica's parrot team. *Dominica Times* 10:13.
- Forshaw JM. 1989. Parrots of the world, 3rd ed., Willoughby, NSW Australia: Landsdowne Editions. 672p.
- Gregoire FW. 1981. The dilemma of the *Amazona imperialis* and *Amazona araucaria* parrots in Dominica following Hurricane David in 1979. In: Pasquier RF, editor. Conservation of new world parrots. Washington, DC: Smithsonian Institution Press for the International Council for Bird Preservation. p 161–167.
- James A, Durand S, Baptiste BJ. 2005. Dominica's birds. Roseau, Dominica: Forestry, Wildlife and Parks Division, U.S. Fish and Wildlife Service Division of International Conservation and Society for the Conservation and Study of Caribbean Birds. p 18–19, 73–74.
- Lowe R. 1984. Endangered parrots. Dorset, UK: Blandford Press. p 59–64.
- Nikolopoulos D. 2000. Against the odds. *Palm Beach Illustrated* 49:72–77, 114–115, 128–129.
- Reillo PR. 2000. Sisserou to the rescue—how an endangered parrot promotes biodiversity protection in Dominica. *PsittaScene* 12: 2–5.

- Reillo PR. 2001. Imperial recovery: Dominica's flagship parrot on the comeback. *Psittascene* 13:4–5.
- Reillo PR, Durand S. 2008. Parrot conservation on Dominica: successes, challenges, and technological innovations. *J Carib Ornithol* 21: 52–58.
- Reillo PR, Durand S, McGovern KA, Winston R, Maximea M. 2000. Reproduction in Dominican Amazon parrots—implications for conservation. *Am Fed Avicult Watchbird* 27:34–39.
- Russello MA, Amato G. 2004. A molecular phylogeny of *Amazona*: implications for neotropical parrot biogeography, taxonomy, and conservation. *Mol Phylogenet Evol* 30:421–437.
- Snyder N, McGowan P, Gilardi J, Grajal A, editors. 2000. Parrots—status survey and conservation action plan 2000–2004. Gland, Switzerland: International Union for the Conservation of Nature (IUCN). p 108–109.
- Wiley JW, Gnam R, Koenig SE, Dornelly A, Galvez X, Bradley PE, White T, Zamore M, Reillo PR, Anthony D. 2004. Status and conservation of the family *Psittacidae* in the West Indies. *J Carib Ornithol* 17:94–154.
- Wright TF, Toft CA, Enkerlin-Hoeflich E, Gonzalez-Elizondo J, Albornoz M, Rodriguez-Ferrado A, Rojas-Suarez F, Sanz V, Trujillo A, Beissinger SR, Berovides V, Galvez A, Brice AT, Joyner K, Eberhard J, Gilardi J, Koenig SE, Stoleson S, Martuscelli P, Meyers JM, Renton K, Rodriguez AM, Sosa-Asanza AC, Vilella FJ, Wiley JW. 2001. Nest poaching in Neotropical parrots. *Conserv Biol* 15:710–720.