

A MANAGEMENT GUIDE FOR THE WHITE-BELLIED CAIQUE PARROT
(Pionites leucogaster xanthomeria)

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Introduction

This report is intended as a technical reference for the husbandry and management of the white-bellied caique parrot (*Pionites leucogaster xanthomeria*). This is an ever-evolving document, in which reproductive, developmental and behavioral information from a closed aviary has been steadily compiled into categories of avicultural interest since 1994. The study population has been resident at the Rare Species Conservatory Foundation (RSCF) in Loxahatchee, Florida since 1988, and affords the opportunity to study a finite, genetically diverse, breeding population under a fixed husbandry protocol over many years.

The white-bellied caique population at RSCF is the source for an in-house Population Management Program (PMP). The main objectives of the PMP are: (1) to develop consistent husbandry practices for the maintenance of *P. leucogaster* in captivity; (2) oversee the demographic and genetic management of *P. leucogaster* in zoological collections throughout North America; (3) encourage public/private cooperation in the management and maintenance of the captive population; (4) collate scientific information for the evaluation and improvement of captive husbandry practices; and (5) develop long-term strategies for conservation in the wild, employing the captive population and its database as a living library for research information and genetic material.

There are five main sections to this report: (1) taxonomy and natural history; (2) husbandry methods; (3) reproductive data from the study population; (4) demography and genetics of the managed population in the PMP; and (5) the PMP studbook. The material presented in each section is sufficiently general for use by zoo curators and professional aviculturists, but also includes specific information derived from the study population which is likely unique in the avicultural literature. Much of the discussion in each section focuses upon management considerations for *P. leucogaster* both within and among zoological institutions and private breeding facilities. The presentation of population-specific information conforms to formats for Population Management Programs and Species Survival Plans, as specified by the American Zoo and Aquarium Association (AZA, 1998).

Taxonomy

Caiques belong to the psittacine genus *Pionites*. Although behavioral similarities between these parrots and those of the genus *Aratinga* and *Pyrrhura* have been noted (Tavistock, 1954; Smith, 1971), morphometric analyses (Thompson, 1900; references in Forshaw (1989)), suggest no close phylogenetic relationship between *Pionites* and *Aratinga* or *Pyrrhura*. Caiques are medium-sized parrots with short, square tails and a sexually monomorphic phenotype (Forshaw, 1989).

White-bellied caiques comprise three sub-species: *P. leucogaster leucogaster*; *P. l. xanthomeria*; and *P. l. xanthurus*. White-bellied caiques are also known as apricot-headed Caiques; in this document we will use the term “white-bellies.”

Description

White-bellied caiques are small parrots, averaging 23 cm in length and 165 g in weight. They are easily distinguished from other parrots by their white breast feathers (Low, 1986). Other obvious features of the species include an orange forehead and crown, extending to the nape. The orange fades to yellow under the chin, meeting a snowy white breast. There are several distinct color variations between the three white-bellied sub-species. All have white under parts, but differ in thigh and tail colorations. Thighs of

leucogaster are green, while both *xanthomeria* and *xanthurus* have yellow thighs (*xanthurus* being paler). For all three sub-species, wing and back feathers are dark green, with wing coverts deep blue. Both *leucogaster* and *xanthomeria* have a short green tail with yellow under-tail coverts. *Xanthurus* displays an entirely yellow tail, including under-tail coverts. The bill for all three is horn colored. Bare skin surrounds the eye, with or without melanistic spots, and nares are pink. Feet of both *xanthomeria* and *xanthurus* are grey-black, with *leucogaster* having pink feet. The three sub-species share a red iris with a grey ring.

Immature birds are sometimes confused with the Black-headed Caique, *P. melanocephala*, because their crown is often marked with black feathers. These feathers are molted out over a period of six months to a year. Further details of plumage can be found in Low (1986) and Forshaw (1989).

Natural History/Status in the Wild (*P. l. xanthomeria*)

Range: Distributed south of the Amazon River, northern Brazil, west to eastern Peru and south to Santa Cruz province and northern Bolivia (Forshaw, 1989). Presence in Ecuador awaits confirmation (Ridgely, 1981).

Novaes (1981) recognizes this species and the largely allopatric *P. melanocephala* as members of a superspecies, pointing out that their close relationship to one another is indicated by hybridization in a narrow contact zone in the western sector of the range and by the presence of scattered black feathers in the crowns of some specimens of *P. leucogaster* from as far east as the Belem district, eastern Peru and northern Brazil (Forshaw, 1989).

White-bellied caiques usually inhabit lowland forests, preferring trees bordering watercourses. Due to the widespread clearing of forest in northern Brazil the species is undoubtedly in decline, although it is still present in several large reserves in both Brazil and Peru (Forshaw, 1989). At the Cocha Casha Biological Station in Manu National Park, southeastern Peru, flocks are normally encountered in the forest canopy and in the trees located in open areas at the margins of lakes (Teborgh et al, 1984).

These parrots generally travel in pairs or noisy family groups. They congregate mainly in the forest canopy, spending most of the day feeding on a variety of fruits, berries and seeds.

On 1 January 1924 a white-bellied caique nest was discovered at Murutucu, Para, Brazil. It was in a hollow tree approximately 30 m above the ground and contained two white eggs, which the female was seen to be incubating. The eggs were noted to be 31 x 25 mm and 30 x 25 mm (Pinto, 1954; c.f. egg data in this volume).

Status in Captivity/Aviculture

Caiques have long been popular aviary birds because of their charming, mischievous personalities. They have been known in avicultural circles since at least 1751 (Low, 1986). White-bellied caiques have always been much rarer in aviculture than *P. melanocephala*, primarily because Brazil curtailed exportation by 1972, whereas *P. melanocephala* was imported from throughout its range (including Guyana) until the Wild Bird Conservation Act was enacted by the U.S. Fish and Wildlife Service in 1992.

White-bellied caiques have been bred privately in the United States since 1932. In 1934 San Diego Zoo reported one chick, and in 1969 Busch Gardens, Tampa produced nine chicks from a *leucogaster* x *xanthomeria* pair (Low, 1986).

Whereas *P. leucogaster* and *P. xanthomeria* are somewhat well documented in avicultural literature, there is scant information available regarding *P. xanthurus*. As of this writing, the U.S. captive population

comprises only *xanthomeria*, save for several hybrid *leucogaster* x *xanthomeria* crosses, and a few male *leucogaster* in private collections. All quantitative information in this report is based upon *P. l. xanthomeria*.

Information regarding clutch size, egg size, incubation and hatch weights will be discussed further in this document under the headings **Breeding** and **Incubation**.

Husbandry

White-bellied caiques have proven to be prolific in captivity. The following information regarding *P. l. xanthomeria* was compiled from 1994-1997 at the Rare Species Conservatory Foundation (RSCF), Loxahatchee FL.

Caging/Nest boxes

White-bellied pairs are housed out-of-doors in 3.5'x9'x3.5' (WxLxH) cages constructed of 1" x 1/2" 14 ga. welded wire. Cages are suspended three feet or more above ground. Feeding stations are situated at the front of the cage. Perch size averages 1.5-2" diameter. Perches are placed generously throughout the cage at different levels. Nest boxes are suspended in the rear of the cage, attached from the outside, level with the roof. Nest boxes are constructed of untreated plywood, sized 13" x 9" x 11". All are bi-level with a 3-5" bed of pine shavings in the lower level. Nest boxes are single entry/exit with latching doors on the side to permit cleaning, monitoring and egg/chick removal.

Diet

In the wild, white-bellied caiques feed on a variety of fruits, vegetables and seeds. There are several manufactured psittacine diets currently available that are suitable for this species. The following diet was developed for use at RSCF.

Ingredients:

Fortified large parrot seed mix

Large, greystripe sunflower seed

Higgins brand "Amazon Crunch" pellets, The Higgins Group Corp., Miami, FL 33166

Zupreme brand monkey biscuit, Premium Nutritional Products, Inc., P.O. Box 2094, Mission, KS 66202

Chopped fruit and vegetable mixture including: apples, citrus (orange, grapefruit, etc.), grapes, melon, cooked sweet potato, corn, peas, broccoli, leafy greens (collards, kale), squash and beets.

The diet is a combination of the seed mix (2:1 mixture of fortified parrot and white sunflower) and the fruit/vegetable mix. Approximately 1 cup of seed and 1.5 cups of fruit/vegetable mix are fed per pair of birds per day. The seed diet is topped with .25 cups Amazon pellets, and one monkey biscuit per bird. A soluble, powdered multi-vitamin (Quiko multivitamin, Quiko GmbH, 46395 Bocholt, Germany) is added to the drinking water, which is changed daily. Cuttlebone is provided for mineral supplementation.

Additional portions of seed, fruit/vegetable mix, millet spray and soaked monkey biscuits are made

available to pairs rearing chicks. The diet is increased proportionately as chicks age, leave the nest box and begin feeding on their own. Diets are distributed once daily between 0800 and 0900 hrs.

Breeding

White-bellies typically lay their first clutch by the third year, although egg laying by the age of 11 months has been recorded at RSCF. Males reach sexual maturity in two to three years. The breeding season in south Florida begins in January and usually ends in June. Clutch size averages four small white eggs, averaging 2.5 cm in width and 3.2 cm in length. Eggs are laid every second or third day. The female incubates the eggs 26 days, rarely leaving the nest box. The male feeds the female while she sits the eggs. The altricial chicks hatch blind with only a few downy feathers, averaging 7.2 g. Both parents feed the chicks by regurgitating partially digested seeds and fruits. Successful clutches of up six chicks have been raised and fledged by parents in captivity.

Artificial Incubation

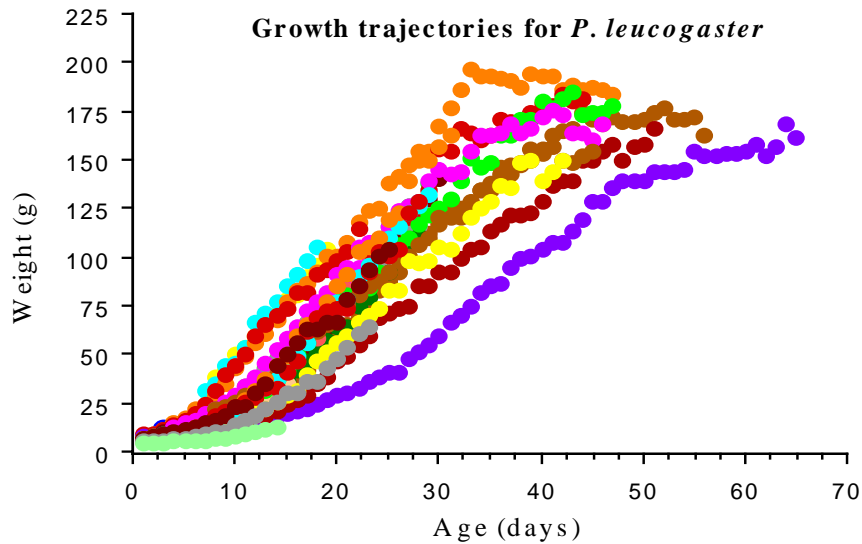
Nestboxes are checked daily during the breeding season, and eggs are removed by 0900. Eggs are then weighed, measured for length and width, labeled for species, date and cage number and placed in an incubator (see details in Egg Analysis section of this report). There are many different styles and manufacturers of avian incubators available, many of which incubate *P. leucogaster* eggs successfully. For the purposes of this document we will refer to the Alpha Genesis Wild Bird Incubator Model 600 (China Prairie Co, Garberville CA). Eggs are placed in rocker trays inside the incubator heated to 37.4 C (99.9 F) with 50% humidity. Eggs are candled twice daily, turned automatically six times daily and turned by hand twice daily (90-120 degrees/turn, unidirectional). The eggs incubate, on average, for 26 days.

Upon pipping, eggs are removed from the rocker trays and placed in a small dish lined with paper towels or soft cotton. The dish is then placed in the rear of the incubator. Upon hatching, chicks are weighed, and hatch date, species and cage number are recorded in a log. All chicks are color coded by brood with a non-toxic water-based marker and placed singly in small plastic cups lined with tissue. Chicks are brooded in commercially available avian brooders or isoletes (Animal Care Products Intensive Care Unit) set at 36.1 C (97 F) and saturation humidity; chicks reared under inadequate humidity produce flaky, dry skin, and often exhibit developmental abnormalities and stunting. Brooder temperatures are lowered with chick age, usually in three to five degree F increments. For example, chicks one through seven days of age are maintained at 97 F, 8-14 days at 95 F, 15-25 days at 92 F, 25-25 days at 90 F, and upon feathering, brood temperature is decreased to 85 F. As weaning commences, temperatures can be lowered to average room temperature (26-28 C, 78-82 F). At any age, overheated chicks appear agitated and flushed, and typically pant and flap their wings, whereas hypothermic chicks appear pale and listless and are cool to the touch. Further information regarding pediatric care and captive breeding of caiques can be found in Worth (1998).



Hand-rearing and Growth Rates

Upon hatching, white-bellies are fed every 90 minutes around-the-clock for the first five to seven days. While most psittacine hand-rearing protocols do not mandate feedings after 2300 hrs, white-bellies seem to require such a regimen for normal development when using commercial hand-feeding formulas. Weighing chicks with emptied crops prior to each feeding has revealed that significant weight gains are achieved between 0 and 0600 hrs. Growth patterns indicate that within the first five to seven days, a weight gain of 15-20% over a single 24 hour period becomes a benchmark for future development. Upon achieving this daily growth rate, chicks “take off,” and weight gains are usually sustained at roughly 15% for the next few weeks. Feeding frequency is reduced with age, with a more typical psittacine regime becoming established after the first week, by which time chicks are fed roughly every 2 1/2 hrs., or whenever crops are completely empty. After the first four to five weeks chicks should be fed four times per day, with the last feeding of the day at 2300-2400 hrs. White-bellies begin showing pin feathers at about the third week, with complete juvenile plumage by eight weeks. The weaning process usually begins by week eight, with chicks fully weaned in 12-14 weeks. Feedings are gradually reduced during this period; weaning is facilitated with dietary additions such as millet spray; soft foods such as banana and soaked monkey biscuit, as well as whole wheat breads, cooked rice, beans and pasta, as well as the full adult diet of seeds and fruits.



Hand-rearing Formula/Tools:

There are many commercially available psittacine hand-feeding formulas, as well as many home recipes (Voren, 1992). White-bellies have been raised with greatest success at RSCF using the following formula.

Ingredients:

Kaytee Exact Handfeeding Formula, Kaytee Products, Inc., Chilton, WI 53014

CeDe Lorifood, CeDe Vofelvoeders BV, St. Ceciliastraat 2, 5038 HA Tilburg, Holland

Beechnut Papaya Tropical Fruit Dessert, Beechnut Nutrition Corp., Canajoharie, NY 13317

Recipe:

3:1 Kaytee:CeDe by volume mixed with 1/5 (of total dry volume) Beechnut; add water to proper consistency.

Formula is fed at 37.5 - 40.5 C (100 - 105 F), heated in a microwave. Formula is mixed fresh for each feeding. Day-one chicks are fed diluted formula with a small plastic Dispo pipette. The formula is diluted with Infalyte (Mead Johnson Nutritionals, Evansville, In 47721). After two to three days undiluted formula (constituted with water only) is fed using plastic single cc syringes. As chicks grow, larger plastic syringes are used to feed larger volumes of formula. Syringes provide an accurate way to monitor and regulate formula volume and are easily cleaned and disinfected. All feeding utensils are thoroughly cleaned after each use and placed in a diluted disinfectant solution (Roccal-D, The Upjohn Co., Kalamazoo, MI 49001). Feedings are increased in volume and decreased in frequency according to growth rates and weight increases. Chicks are fed until the crop is full and rounded, but not distended, and there is much variation in crop capacity for chicks of all ages. At RSCF, crops are filled by appearance, not by a predetermined volume; hence we do not provide an index of (formula volume)/age or volume/size for reference.

Housing/Exhibit Design

This section offers suggestions for exhibiting white-bellied caiques, applicable to both public and private facilities. White-bellies are easily flocked, and do very well in large, free flight, multi-species exhibits, as long as certain species-specific behaviors and characteristics are taken into consideration. White-bellies are known to be poor flyers with little stamina (Low, 1989). This can present a challenge when housing these birds in larger exhibits with other species. The simple solution is adequate perching. A variety of perches (branches, snags, etc.) placed at different levels throughout the exhibit, with flight paths in mind, should prove sufficient. White-bellies are also notorious chewers. Perch placement is a key consideration when housing white-bellies in landscaped exhibits. Offering perches placed some distance away from landscape foliage should reduce the temptation to destroy it. Offering browse (tree trimmings, leaf cuttings, heavily barked perch material, etc.) provides enrichment and helps save permanent landscape trees and shrubs from being stripped. Placing primary perches higher in the exhibit than the landscape plants will also help, as white-bellies, like most psittacines, prefer to congregate in the upper levels of their exhibits.

Although white-bellies are not aggressive by nature, they do have a tendency to be “picked on” by other larger psittacines when housed together. Again, proper perching is a simple solution to many problems. Perches can be placed in “zones” creating spaces for white-bellies to congregate away from other areas of the exhibit. Proper nest boxes also provide a safe haven for birds seeking privacy or escape, and are essential for sleeping, as white bellies sleep communally in nest boxes throughout the year. Nest boxes should be placed high in the exhibit, with enough space between each one to reduce territorial fighting from nesting birds. One nest box per pair or trio of birds is recommended. Visual barriers can be created using small trees and shrubs. Physical barriers can also be fabricated from a variety of stainless steel meshes designed specifically for aviaries (Phantom Mesh, Vanishing Mesh, Zoo Mesh, etc.). Such barriers can be “hung” in panels, thus partitioning the exhibit. Meshes are becoming quite popular due to their durability, flexibility and aesthetics. Proper use of these materials can provide exciting, safe, inter-active exhibits while creating the illusion of open space.

Proper feeding station design and placement will also reduce aggressive behavior among flocked species. Feeding stations should be placed throughout large exhibits, with one station per pair or trio of birds. Feeding bowls should be large enough for two or more birds to feed comfortably. White-bellies, like many psittacines, are very social and will feed in groups as long as the feeding stations are adequate in size. Water bowls should be large enough to encourage and permit bathing.

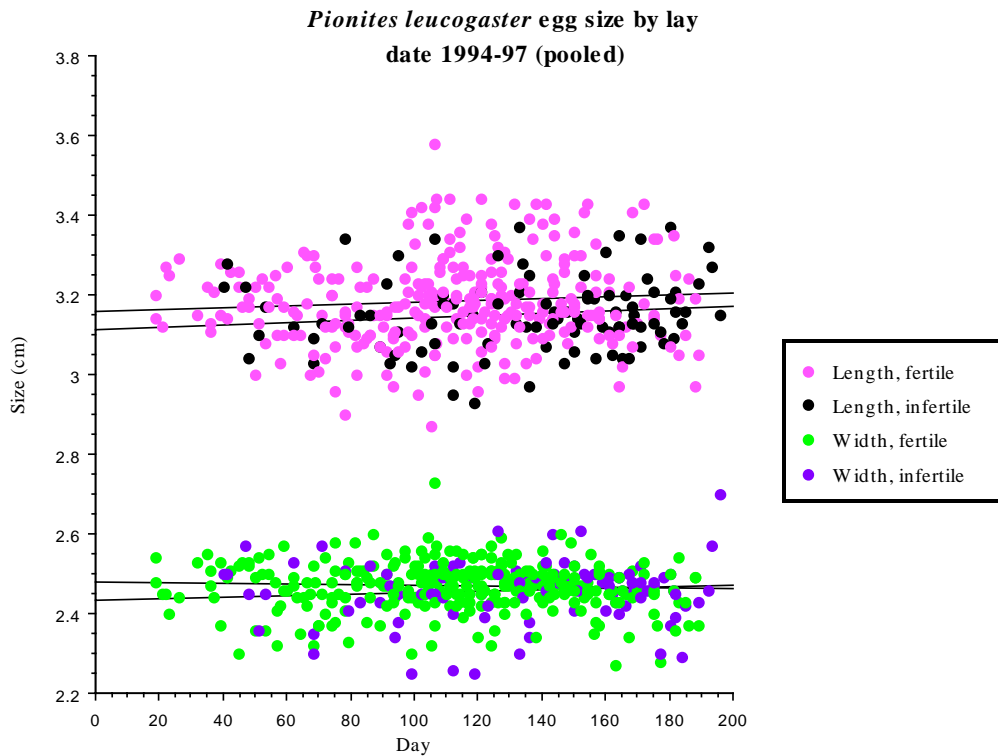
Reproductive Data

Materials and methods: *Pionites leucogaster* eggs were collected within 24 hours of oviposition throughout the entire breeding season, years 1994-1997. For each egg, weight to within 0.1 g was obtained using a digital scale (Tanita, model 1476), and length and width to the nearest 0.01 mm were measured with Vernier calipers. Lay date and breeding pair identification number were recorded on each egg (with a fine sharpie) and in a master log. Eggs were incubated in an Alpha Genesis Model 600 incubator at 37.4 C and 50% relative humidity, with automatic 180-degree egg rotation every 4.5 hours and 60 degree manual rotation (unidirectional) every 12 hours. The fate of each egg was tracked, with notes on fertility, embryonic death (and date), embryo positioning, hatch assistance, hatch date, open umbilicus, and relevant health measures. Upon hatching, chicks were weighed to the nearest 0.1 g and identified by brood using water-soluble markers applied to downy feathers. All chicks were hand-raised using the feeding formula detailed in this report. Where referenced, growth trajectories were obtained by weighing chicks to the nearest 0.1 g every morning prior to the first feeding of the day, when crops were completely empty.

Data analysis: Egg data were transformed into a spreadsheet format using Statview II for Macintosh, and Staview 5.0 for Windows (SAS Institute, Inc., Cary, N.C.). For allometric comparisons, egg volume was approximated by computing the volume V of a cylindrical egg of length L and width W . Egg density was approximated by the ratio of egg weight to V . For the descriptive scope of this paper, univariate, parametric statistics were computed from internal program routines, with post hoc analyses applied as per Keppel (1982) and Sokal and Rohlf (1973). Large sample sizes and homogeneous variances (evaluated with ratio F-tests) allow these more easily interpreted parametric results to be summarized without sacrificing statistical power. However, we adopt the convention that both parametric and (appropriate) nonparametric tests must satisfy $P \leq 0.05$ for the null hypothesis to be rejected.

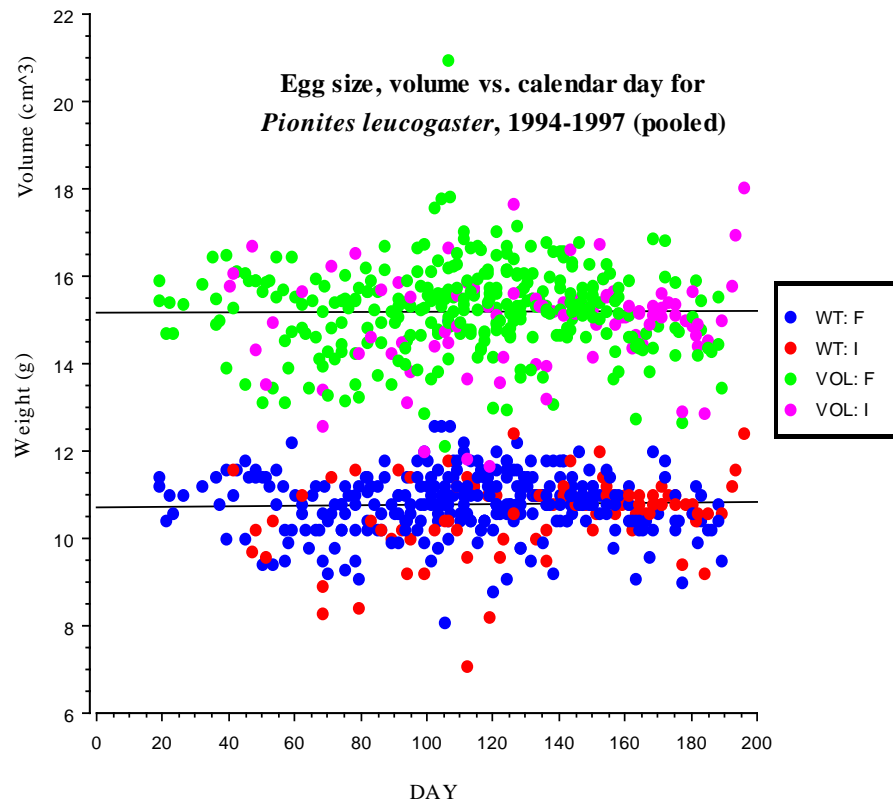
The complete dataset is presented in spreadsheet form in Appendix I, and can be acquired on disk or via e-mail in a variety of analytical and text formats from the senior author.

Results and discussion: A summary of univariate statistical tests is presented in Appendix II, highlights of which will be discussed here. Various indices of egg size generally correlate positively, and significantly, with fertility. For 1994 data, fertile eggs were significantly heavier and more dense than infertile eggs (unpaired t-test, $df=1,96,97$, $P<.0085$). For 1995, fertile eggs were significantly longer, heavier, and of greater volume than infertile eggs (unpaired t, $df=1,77,78$, $p<.04$). For 1996, fertile eggs were significantly longer (unpaired t, $df=1,87,88$, $P=.0003$). In 1997, density was found to be significantly greater in infertile eggs ($df=1,123,124$, $p=.0062$) despite no significant differences in egg dimensions.



The timing of oviposition of fertile and infertile eggs was found to be statistically discernable in all years but 1994, which has the fewest data. For the 1995-97 breeding seasons, the mean of all calendar days on which fertile eggs were laid was significantly less than the mean for infertile eggs (1995: fertile = day 114.911 ± 44.659 , infertile = day 155.652 ± 21.448 , t-test, $df=1,77,78$, $p=.0001$; 1996: fertile = 118.439 ± 39.355 , infertile = 151.043 ± 25.458 , t-test, $df=1,87,88$, $p=.0004$; 1997: fertile = 117.087 ± 35.18 , infertile = 146.92 ± 38.31 , t-test, $df=1,126,127$, $p=.0003$).

Timing of egg laying differed significantly among breeding pairs for all years except 1997, when an unusually synchronous season was observed (1-way ANOVA, calendar days vs. broods, $p=0.0852$). Pairs tended to be consistent in rank order of mean lay date, with the same pair (#37) reproducing earliest in every season. Significant differences in reproductive timing between pairs arise from the degree to which pair #37 preceded egg laying in other pairs. No significant differences in mean lay dates were detected among pairs (omnibus F) when #37 was excluded from the analysis of variance.



Significant differences among breeding pairs in the various egg dimensions were seen both within and between years (Appendix II), suggesting that breeding pairs are a main effect with which to partition variance in egg size and density. As with timing of oviposition, pairs were consistent in their rank orders of size measures across years, with small-egg producers and large-egg producers factoring out to the same breeding pairs each year. The uniformity of husbandry conditions for this population strongly suggests a physiological, and likely genetic, basis for such consistent reproductive differences. Similarly, fertility, expressed as a frequency within seasons, carries a brood component, with a consistent rank order of fertility falling across the same breeding pairs each season. No significant differences were detected in egg dimensions across the breeding season, both within and between breeding pairs, regardless of year. The uniformity of egg size over time suggests that egg scaling itself has only a nominal influence on overall fertility within the population. However, the demonstrable trend toward larger, fertile eggs earlier in all breeding seasons (above) argues strongly for a limited-resource-based component to fertility, such as a differential allocation of nutrients toward egg proteins over time. Thus, the absence of significant egg size

vs. time correlations, both within pairs and overall, is problematic.

For all hatched eggs, hatch weight strongly and significantly correlated with egg size, but not egg density (Appendix II). As eggs were measured on the lay date, a density correlation is unexpected, even though, as reported previously, fertility is positively correlated with egg size and density as estimated on the lay date. These observations warrant additional comment. To our knowledge, ours is the only quantitative analysis of psittacine eggs to date that has revealed a significant relationship between egg size or weight per unit volume and fertility. The relationships are strong enough to discriminate a fertile from unfertile egg on the lay date by size measures alone, days before candling would reveal the presence of an embryo. Any physiological explanation for the density differences between fertile and infertile eggs at such an early stage rests upon assumptions about early cell division and the role of fertilization in catalyzing measurable changes in the albumen. Such hypotheses are necessarily speculative, and cannot be entertained with the available data. Alternatively, density-driven variances between fertile and infertile eggs may be incidental or relict, a product of pre-zygotic selection that would tender insufficiently dense ova to become infertile; such eggs might pass through the oviduct without an opportunity for fertilization (e.g., timing incompatibilities, behavioral cues), or might be incapable of sustaining sperm long enough to complete fertilization. Similarly, longer, wider and heavier eggs may simply represent more viable eggs; that is, the first principal component of egg measures loads significantly on fertility as a main effect. Variance in egg size can become a determinant of fertility, and therefore fecundity, via the differential allocation of reproductive effort within clutches over the breeding season. We have shown here that egg dimensionality provides a convenient estimator for such reproductive effort; egg size thus can be conceptualized as a fertility scalar in *P. leucogaster*.

As noted above, the simple correlation of egg size and fertility masks the overall, across-season pattern of egg size uniformity, even though fertile eggs have a significantly earlier mean lay date than infertile eggs. This paradox is most easily explained by behavioral, rather than physiological, mechanisms. First, the breeding population is nearly synchronous in the onset and cessation of reproduction, which defines the breeding season for our analysis. Fertility is scattered throughout the sequence of eggs laid by individual pairs, as well as the entire population, with a slight, but significant skew toward fertility early in the season. Alternatively, we might interpret this tendency as a cumulative incidence of infertility over time, increasing with each day of the breeding season. In either respect, fertility has a stronger temporal component than it has a physical one (as estimated by egg size), which, when stacked on top of the size/fertility analysis appears as an independent main effect. Indeed, there are no significant interactions between size/time and fertility, because size has no discernable variation over time.

We can postulate that mating behaviors drive these patterns, because reproductive behaviors in *P. leucogaster* in captivity are well known. Birds must copulate within 48 hours of laying in order for the resultant egg to be fertile; sperm storage for greater than 48 hours has not been observed in any small psittacine. During the breeding season, caiques copulate daily, and usually more than once per day. Since birds are housed in small breeding groups or pairs, but within sight and earshot of one another, there no doubt exist many visual and auditory cues to stimulate and reinforce reproductive behaviors throughout the season. Strong evidence for such intra-specific influences come from flight cage manipulations in our aviary: young birds housed within view of mature pairs initiate mature sexual behaviors within two years (with fertile eggs recorded at 11 months of age), whereas birds housed away from breeding groups never lay fertile clutches before age three.

The general reproductive patterns in *P. leucogaster* include a synchronous onset of egg laying, a relatively strong temporal component to fertility, with an observable advantage attributed to early reproductive success (as in most birds [Wilson, 1984]), and a relatively uniform allocation of nutritional resources to eggs, evident by the flat size/time correlation. Since the study population was not permitted to incubate eggs, nor was food or nest-site limited, we can extrapolate general conclusions about reproductive capacity in this species from the observed behaviors. Clearly, seasonality is independent of food or nest availability:

birds are provided with super-optimal resources throughout the year. Hence, the onset of reproductive behavior is likely driven by environmental and seasonal factors, such as temperature, photoperiod, rainfall or humidity. Such seasonality in onset of reproduction is the basis for life history variation; those individuals capable of early reproduction, by capitalizing upon operant conditions, will convert reproductive effort into to successful representation in the next generation more quickly. Moreover, the resultant fledglings will be the oldest of the recruited population that year, affording a similar advantage to early reproduction upon sexual maturity, which can be realized as early as the following breeding season. (By extension, only such early hatchlings could possibly be sexually mature by the following year, confirming the early advantage to both parents and young.)

Those fertile eggs toward the end of the season, while disadvantaged chronologically, represent an important insurance policy for breeding pairs. The incredible multi-clutch capacity exhibited by *P. leucogaster* illustrates the enormous resilience (Holling, 1973) of this species: caiques can produce many-fold the typical clutch size when eggs are naturally incubated. Such investment supports the idea that reproductive effort can be sustained, even in the face of multiple clutch failures (removal of eggs represents failure to the hen), so long as nutritional and nesting resources and access to a compatible mate are provided. Our study population is pushed, reproductively, to capacity by removing all eggs; the determinants to variation in reproductive success must be attributed to the translation of resources, over a finite season, to eggs, coupled with the constancy of successful copulation between mates.

Cumulative infertility frequencies over breeding seasons suggest that there are limits on the conversion of physical resources to offspring. Some factors, such as nutritional state of the hen after continuous egg laying, are obvious, and likely set the rate at which nutritional resources are invested in reproductive effort. Other rate limiters are more obscure, such as mating tolerance between males and females over an extended breeding season, or the attenuation of responses, between mates, to sexual cues (e.g., copulation frequency and/or duration in response to hen's solicitation; timing lapses between optimal copulation and actual egg position in the oviduct).

The eventual cessation of egg laying, denoting the end of the breeding season, represents the final exhaustion of reproductive effort, which for many hens follows at least a short sequence of infertile eggs. Whatever environmental cues, nutritional resources or physiological mechanisms ultimately set this upper limit of reproductive output is unclear. However, birds permitted to raise their own young through fledging exhibit little or no seasonality in reproduction in this study population, and often begin to lay a new clutch within several weeks of fledging the previous clutch. This potential for aseasonality under typical aviary conditions here suggests that continuous removal of eggs as they are laid pushes reproduction, via multi-clutching, to the maximum rate, until a physiological ceiling on reproductive output is reached. Thus the seasonal breeding often observed in *P. leucogaster* in captivity may result from a complex interplay among behavioral exchanges between mates, availability of food resources and how efficiently they are metabolized, environmental influences (temperature, photoperiod) and the frequency with which birds parent-rear their young.

Demography and Genetics

As shown in the **Reproductive Data** section of this report, white-bellied caiques can be prolific breeders in captivity. The population derived from the bloodlines in the white-belly PMP will likely surpass 200 birds within the next few years. Since Brazil officially curtailed all exportation of white-bellies in 1972 (see also Wild Bird Conservation Act, U.S. Fish and Wildlife Service, 1992), future captive populations will be

completely dependent upon founder stocks resident in the U.S. Fortunately, there is sufficient founder representation within this program to ensure high heterozygosity for several generations as the population increases.

Recommended population size:	<500
Current population size:	24.22 (46)
#participating institutions:	10
#hatches last year:	31 (PMP pop'n comprised of birds hatched in 1997)
#deaths last year:	2
#imports last year:	0
#exports last year:	0
Current growth rate:	lambda 1.07
	Ro 1.870
	r .068
Generation time (T):	9.24
	(artificially high T due to previous generations of offspring surplus outside of PMP population and lost to follow-up analysis)

The genetic profile of the PMP population is based upon all founders and their living descendants, the latter of which comprise the future breeding population for the PMP. The analysis is based upon 70 (36.34) birds of which 46 (24.22, above) represent the living, base PMP group. 20 birds that can be traced to the wild found the original population; all birds in the population have known pedigrees.

Gene diversity in managed population:	0.942
Founder genome equivalents:	8.580
Descendant population mean kinship:	0.0583
Number of founders for living descendant pop'n:	10.10 (20)
Population mean inbreeding coefficient:	0

Conservation/Program Prospects

Pionites leucogaster is not presently considered a species of high conservation priority (AZA North American Parrot Taxon Advisory Group, 1997 Regional Collection Plan). However, as a social parrot easily adapted to captivity, caiques offer many research opportunities germane to conservation initiatives with other psittacines. Just 15 years ago white-bellies were considered very rare in aviculture, and the North American population totaled 50 birds or less, with only sporadic breeding. With the advent of sophisticated incubation techniques and much-improved, commercial hand-feeding formulas, zoological institutions and private aviaries alike have successfully raised caiques. Much of the reproductive and developmental information contained in this report is undocumented for other parrots; the caique's sheer productivity has enabled a broad database to be compiled.

The conservation prospects for most parrots hinge primarily upon assessments of population viability in the wild, and secondarily upon husbandry and management potential. As populations of many parrot species decline in nature, the imperative for captive stewardship, from which wild populations might be supplemented or restored, becomes apparent. Captive breeding programs can be vital to thwarting extinctions, particularly when wild populations decline so rapidly and dramatically that *in situ* mitigative efforts become essentially useless. Often, the field data requisite to rendering a viability assessment for a parrot population takes years to accumulate, by which time a species in decline may not be responsive to

field-based conservation efforts alone.

One of the inspirations for the white-bellied caique PMP, and this report, was the remarkable growth rate observed in the North American population following a ten-year period of concentrated avicultural interest. Such resilience offers hope, not only for the preservation of caiques, but also for parrots with similar life histories, demographics and genetic profiles. As a model species, white-bellies remind aviculturists and zoologists of the need to collect as much information from living collections as possible, and to track captive populations vigilantly. If captivity is to provide a refuge for wildlife, population managers and wildlife breeders must act concertedly to preserve both the living representatives and the data they contain.

The future of the white-belly program depends upon cooperation and exchange of information among aviculturists and conservation biologists. With an established breeding program, genetic database and husbandry protocol, the white-bellied caique can be maintained in captivity indefinitely. If and when needed, this program may assist in the restoration of wild flocks and serve as a template for recovery plans for other parrots. The authors also hope this report inspires collection managers and aviculturists to compile similar information from captive populations of other species.

Population Management Program

In January 1998, the Rare Species Conservatory Foundation (RSCF), 1222 "E" Road, Loxahatchee, FL 33470 and the Palm Beach Zoo at Dreher Park (PBZ), 1301 Summit Blvd., West Palm Beach, FL 33405, became partners in the development of the White-bellied Caique Population Management Program (PMP). Paul R. Reillo, Ph.D., Director of Conservation and Research for the Zoo and President of RSCF, is PMP Species Coordinator. As of this writing, 15.15 white-bellies have been loaned to PBZ by RSCF. PBZ has placed these birds in eight American Zoo and Aquarium Association (AZA) accredited U.S. institutions. These birds have zero inbreeding and known pedigrees (see **Demography** and **Genetics** section). Through the PMP, caiques are made available to all AZA institutions at no cost, and to private aviculturists who wish to participate in the program at a nominal cost per bird (Appendix III). As the new, managed population grows, the PMP will coordinate exchanges between participating institutions and aviaries to find compatible mates for progeny and maximize outbreeding. The invitation to private aviculturists to participate in the PMP is included in the Appendix. The following are current institutional participants in the white-belly PMP, with contact persons and phone numbers:

Beardsly Zoological Gardens
1875 Noble Avenue
Bridgeport, CT 06610-1600
Don Goff, General Curator
(203) 394-6564, (203) 394-6566 [Fax]

Bronx Zoo/Wildlife Conservation Park
2300 Southern Boulevard
Bronx, NY 10460-1099
Don Bruning, Ph.D., Ornith. Chair/Curator
(718) 220-5154, (718) 220-3133 [Fax]

Central Park Zoo (WCS Conservation Center)
830 Fifth Avenue
New York, NY 10021-7095
Don Bruning, Ph.D, Orbith. Chair/Curator, Bronx Zoo
(718) 220-5254, (718) 220-3133 [Fax]

Chaffee Zoological Gardens of Fresno
894 West Belmont Avenue
Fresno, CA 93728-2891
Dr. Sue Lynch, DVM
(209) 498-4978, (209) 264-9226 [Fax]

Detroit Zoological Park
P.O. Box 39
Royal Oak, MI 48068-0039
Thomas Schneider, Curator of Birds
(248) 398-0903, (248) 398-0504 [Fax]

The National Aviary in Pittsburgh, Inc.
Allegheny Commons West
Pittsburgh, PA 15212-5246
James Bonner, Curator of Birds
(412) 323-7235, (412) 321-4364 [Fax]

Palm Beach Zoo at Dreher Park
1301 Summit Boulevard
West Palm Beach, FL 33405-3098
Karen McGovern, Conservation
(561) 790-5864, (561) 792-2122 [Fax]

Santa Anna Zoo
1801 East Chestnut Avenue
Santa Ana, CA 92701-5001
Connie Sweet, General Curator
(714) 647-6575, (714) 953-7401 [Fax]

White-bellied Caique Studbook

The PMP is based upon historical information on the living population. The demographic and genetic profiles of the population through time are dependent upon the accuracy of the original information used to compile the studbook, and precise record keeping as the population grows. The PMP is overseen by the Rare Species Conservatory Foundation, with participating institutions and individuals reporting all events (e.g., reproduction, death) to the PMP coordinator. The studbook follows a format established by the International Species Information System (ISIS, 12101 Johnny Cake Ridge Rd., Apple Valley, MN 55124-8151) using their Single Population Animal Records Keeping System (SPARKS). Studbook materials are presented in this report in as produced by SPARKS software, with each subsection identified in the header of the first page of that section. Studbook reports and page numbers are as follows:

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