A CRITICAL ANALYSIS INTO THE CAPTIVE MANAGEMENT VARIABLES SURROUNDING THE OCCURRENCES OF REGURGITATION IN HAND REARED SPIX'S MACAWS *CYANOPSITTA SPIXII* AT AL WABRA WILDLIFE PRESERVATION

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ABSTRACT*:* The Spix's macaw (*Cyanopsitta spixii*) is one of the most critically endangered bird species in the world and in 1990, the Brazilian Nature Conservation Authority established a permanent committee to oversee the captive breeding of about twenty individual Spix's macaws held in various locations throughout the world. Al Wabra Wildlife Preservation (AWWP) successfully bred ten Spix's macaws in the 2005 and 2006 breeding seasons but intermittent episodes of post-feeding regurgitation in hand-raised chicks prompted the need to better understand and monitor the nutritional and physiological requirements of growing nestlings. We undertook a critical analysis of the feeding, growth and health data recorded for each individual hand-raised chick in order to ascertain and rank the possible causes of regurgitation in chicks. Parameters such as the total daily food intake, growth curves, nursery room climate (temperature and humidity) and nutritional requirements were investigated as well as any health issues. Chicks attained a maximum body weight of 375 ± 25 g at 45 days and then gradually lost weight until they reached a weaning BW of 300 ± 30 g. The maximum daily volume of food that each chick received was 101 ± 29 g and this occurred at 42 days of age. This was also the age that experienced a peak in post-feeding regurgitation episodes. The total daily feed intake as a percentage of BW peaked (83.1 ± 12.3%) at day 3 of age and dropped to 30.1 ± 2.3% by day 45 and then to 19.6 ± 1.1% at day 92. Detailed analyses of the 2005 and 2006 hand rearing records indicate that the regurgitation episodes may primarily be the result of over-feeding (meal volume overload) during the second trimester of hand rearing. It is predicted that smaller meals during the period where chicks are attaining their maximum body weights may contribute to a decrease in the occurrence of regurgitation episodes in hand reared Spix's macaws.

INTRODUCTION

The Spix's macaw *Cyanopsitta spixii* is one of the most critically endangered bird species in the world (IUCN,2007) and presumed extinct in the species natural range in the *Caatinga* region of northeast Brazil. Trapping and the loss of the native "caatinga baiana" or savannah scrubland, habitat contributed to the species decline (Collar,1997) and the last known wild individual disappeared at the end of 2000. Fortunately, in 1990, the Brazilian Nature Conservation Authority (IBAMA) established a permanent committee for the recovery of the Spix's macaw and there are currently 68 birds in an international managed captive breeding program. Al Wabra Wildlife Preservation (AWWP)

in the State of Qatar, owned by Sheikh Saoud Bin Mohd Bin Ali Al-Thani successfully bred fourteen Spix's macaws in the 2005, 2006 and 2007 breeding seasons, and has a total current captive population of 52. The intention of the AWWP Spix's macaw captive breeding program is to provide individuals for potential future release into their native habitat in North-eastern Brazil.

In 2004, proventricular dilatation disease (PDD) was confirmed responsible for the death of three adult Spix's macaws at AWWP. Despite intensive treatment all three birds developed advanced gastro-intestinal or central nervous disease and died between April 2004 and January 2005 (Hammer *et al.*, 2005). These three birds were part of a group of twenty five individuals that had been transferred from a facility in the Philippines to AWWP in November 2003 and January 2004. Fortunately, in-contact birds have not developed clinical signs of PDD but irregular occurrences of transient post-feeding regurgitation in hand-raised chicks were of concern in a PDD affected population, and prompted the need to better understand and monitor the feeding and physiological requirements of hand-raised nestlings. In this paper we present a critical analysis of the growth data recorded for each individual hand-raised chick reared in 2005 and 2006 in order to ascertain the possible causes of the regurgitation in chicks. Parameters such as the total daily food intake (TDFI), growth curves, environmental factors (temperature and humidity) and nutritional requirements were investigated as well as underlying possible health issues.

MATERIALS AND METHODS

Al Wabra Wildlife Preservation hand-rearing facility

AWWP is a privately owned wildlife breeding and research facility located on a 2.5 km^2 area close to the town of Al Shahaniyah in central Qatar[*]. The facility has a high success rate in breeding difficult and sensitive animals and it is not open to the visiting public. The experienced staff have successfully bred and hand-raised several other endangered avian species. Due to the extremely high environmental temperatures (up to 45°C) reached in the Qatari Desert during the summer months, hand-raised birds were held in separate temperature-controlled incubation and hatching rooms and then onto rearing rooms maintained at 25°C to 28°C. Room temperatures were monitored and recorded up to ten times per day. For the first 35-40 days the Spix's macaw chicks were housed inside a brooder where the temperature and humidity levels were monitored. Brooder temperature for newly hatched chicks began at 36.5°C and gradually and carefully decreased to a room temperature of approximately 28°C by 35 days of age. From here the chicks were moved to a larger holding cage, where the room temperature was maintained at 25°C to 28°C.

Strict quarantine regulations were followed when working with the Spix's macaw and this included the requirement for staff to change clothes and shoes before entering the nursery area. Staff were also required to observe strict hygiene controls including hand-washing between stations within each room of the facility.

Hand-rearing formula

Several commercially available hand-rearing formulas including Kaytee Macaw Exact Hand Feeding Formula (Kaytee Products Inc, Chilton, WI, USA) and Nutribird A19 and A21 (Veresele-Laga, Deinze, Belgium) were used to feed nestlings. Kaytee Exact Macaw Formula was the preferred formula to use

[*] http://awwp.alwabra.com

for rearing larger macaw species and was used to feed the first three chicks (chick 1- 5158, chick 2- 5170 and chick 3- 5829) reared during the 2005 breeding season. Nutribird hand rearing formula was used to feed the seven chicks (chick 4- 6353, chick 5- 6347, chick 6- 6359, chick 7- 6200, chick 8- 6212, chick 9- 6299 and chick 10- 6293) reared in 2006. Macaw chick 4- 6353, chick 5- 6347 and chick 6- 6359 were fed Nutribird A19 until they were 3 weeks of age and then A21 thereafter. Whereas chick 7- 6200, chick 8- 6212, chick 9- 6299 and chick 10- 6293 were only fed Nutribird A21. Nutribird A19 contains slightly more fat than Nutribird A21 and, according to the manufacturer, is suitable for young birds like macaws, eclectus parrots (*Eclectus roratus*) and African grey parrots (*Psittacus erithracus*) that need a concentrated energy diet. All formula, pellets and processed foods were checked before use to ensure the use by dates had not expired as well as ensuring that all foods had been stored correctly and were not contaminated.

Record keeping

All chicks were assigned a unique identification number and name, this and other relevant data such as the chick's parentage, hatch date and hatch weight was recorded on a nursery record sheet (Fig 1).This subsequently became a part of the Individual Record (IR) of each bird along with health and management data. Before and after each feeding, each chick was weighed and body weights recorded for each feed along with the chick's demeanour and other observations such as the temperature and humidity. For reference, the mean body weight of adult Spix's macaws at AWWP was 318 g for males and 288 g for females and a pair was offered 120 g of a maintenance diet per day. In addition birds may or may not consume supplementary fresh fruit and vegetables provided daily. It is estimated that individual adults consume approximately 30-40 g of maintenance diet per day.

Hand rearing methodology

For the first 3-5 feeds newly hatched chicks were fed a mixture of sterile lactated Ringer's solution containing 1% glucose and a parrot-specific *Lactobacillus* species (Institute for Avian Disease, LMU, Munich, Germany). This was provided every 1½ - 2 hours to prevent dehydration. After these initial fluid feeds, the neonatal chicks were gradually introduced to increasing concentrations of formula and by 7 days of age each feeding consisted of formula mixed 25% (w/w) with bottled water. This was increased to a mixture of 27-30% (w/w) with water at between 30-50 days of age. Feeding formula was mixed to a smooth consistency and warmed to a temperature of 40–42ºC for young chicks and 36–40ºC for older chicks. Chicks were fed by a 3 mL transfer pipette for the first fourteen days before switching to tube-feeding using a syringe and soft silicon tubing. Disposable surgical gloves were used for mixing feeds and handling chicks. All feeding equipment was cleaned and disinfected along with all bench tops and floors on completion of each feed.

All water used for rinsing rearing equipment, washing fruit and vegetables, drinking water and formula preparation was filtered through a "So Safe" triple filter (triple ultraviolet water purifier, So-safe Products LLC, Sharjah, United Arab Emeritaes), which involved a primary 5 µm pre-filter, a 1 µm activated carbon filter and final UV sterilisation.

Health and Disease Monitoring

It was normal practice for all chicks to have buccal and cloacal swabs taken weekly for microbiological culture. Swabs were taken immediately before tube feeding or before feeding solids. Food samples were also regularly sampled for microbiological culture. All samples were taken to the AWWP laboratory immediately after collection. Signs of possible food aspiration or illness such increased

respiratory sounds, sniffling, snicking, coughing, abnormal behaviour were investigated by veterinary examination and microbiological culture where indicated.

RESULTS

Chicks attained a maximum body weight of 375 ± 25 g at 45 days and then gradually lost weight during the weaning period until they reached a fledging body weight (BW) of 300 ± 25 g (Fig 2). The maximum daily volume of food that each chick received was 101 ± 29 g and this occurred at 42 days of age. This was also the age that experienced a peak in post-feeding regurgitation episodes. Post-feeding regurgitation events were observed as periods where the chick used rhythmical pumping of the head and neck in a way to return food from the crop to the oral cavity. The total daily feed intake as a percentage of BW peaked (83.1 ± 12.3%) at day 3 of age and dropped to 30.1 ± 2.3% by day 45 and then 19.6 ± 1.1% at day 92.

Humidity levels for the first thirty days were maintained between 45% - 65% but varied considerably (27% to 71%) for the remaining rearing period. There appeared to be no correlation between temperature or humidity variables and episodes or the onset of post-feeding regurgitation in any of the chicks. Chick 3 first regurgitated at day 17 when the temperature was 33ºC with a final regurgitation at 89 days of age. Chick 8 regurgitated less than ten times during its entire hand rearing period whereas chick 7 started regular regurgitation at day 33 when the temperature was 27ºC. Episodes of post-feeding regurgitation continued up until 89 days of age when the temperature had decreased to approximately 26ºC. Chicks 9 and chick 10 were hatched and reared together and chick 9 regurgitated more frequently compared to chick 10. Chick 9 first began to regurgitate at 16 days of age and continued up until 63 days of age, with only a few days without any regurgitation observed. At 29 days of age chick 10 regurgitated for 5 days in a row and then again for a period of 16 days in a row from 41 days of age and three more times at days 63, 70 and 80 days of age.

Chicks 4, 5 and 6 were hatched and reared together. Frequent post-feeding regurgitation episodes for chick 5 began at day 24 through to day 44 and only 2 times after this; once at age 47 and 63 days, respectively. Chick 4 regurgitated at least once after feedings on day 27 through to day 67. Chick 6 regurgitated once daily after feeding on days 28, 29, 37, 38, 42, 45, 51 and 54.

Growth records for individual birds

Despite very frequent episodes of post-feeding regurgitation Chick 3 reached a maximum body weight of 394 g at 44 days of age and maintained a growth rate and fledging body weight similar to the other chicks. In an effort to minimise the regurgitation, daily food intake was reduced on alternating days by about 20% from day 25 through to day 45 to try and reduce the regurgitation occurrences (Fig 3). This was primarily achieved by feeding twice daily instead of the more usual 3 feeds per day at this stage of development. However, regurgitation episodes did not decrease and increased on days 41 to 43 and the bird continued to regurgitate until day 89. From day 46, the TDFI decreased continually until the bird was weaned.

Chick 9 reached a maximum body weight of 350 grams on day 48 and regurgitation episodes started at 29 days of age and occurred each day for the following 5 days. From day 41 through to day 57, regurgitation episodes continued.

Chicks 1 and 2 raised during the 2005 season attained significantly higher maximum body weights of 470 g and 522 g respectively, but not fledging body weights (Fig 4). Although accurate recordings of

each regurgitation event were not made, staff notes confirmed that both of these chicks frequently regurgitated after feeding even during the early hand rearing period.

In the analysis of the growth rate data these two birds (Fig. 4) were treated as outliers. Using SigmaPlot 7.0 the first 50 days of growth rate data for the remaining 8 chicks was used to define the logistic regression curve below (and Fig 5).

Health and Disease

No potential pathogens were isolated from water or food samples but mixed cultures of presumed non-pathogenic Gram positive cocci and rods were the main bacteria isolated from cloacal swabs (n=50) and buccal cavity swabs (n=42). In chicks aged 37 days or older, potentially pathogenic bacterial isolates occasionally or intermittently cultured from cloacal or buccal isolates and never as pure heavy growths. On 3 occasions low numbers of mixed growths containing *Escherichia coli* were cultured from cloacal swabs. Similarly *Pseudomonas aeruginosa* was cultured once from a cloacal swab from a chick aged 123 days and 11 times from buccal swabs from other chicks. On one occasion *Yersinia enterolitica* was cultured from a cloacal swab of a chick aged 81 days. *Citrobacter freundii* was cultured once from the buccal cavity of one chick aged 61 days; a *Klebsiella* species was isolated from one chick aged 110 days; and an *Enterobacter* species was cultured once from the buccal cavity of a chick aged 52 days. Yeasts morphologically consistent with *Candida* species were occasionally cultured from the buccal cavities (n=7) and twice from cloacal swabs of four chicks aged 27 days or older.

Oral antimicrobial therapy such as Enrofloxacin suspension (BAYTRIL® 0.5%, Bayer Vital GmbH, Germany) at the dose rate of 15mg/kg BW twice a day for 5 days was used occasionally for prophylaxis following the isolation of potentially pathogenic bacterial isolates. Nystatin (MYCOSTATIN® Oral Suspension, 100 000IU/ml, Squibb Industria Farmaceutica, Barcelona, Spain) at the dose rate of 0.03ml/10g BW once a day for 10 days was also used occasionally for prophylaxis against potentially harmful yeast infections.

DISCUSSION

Under natural conditions nestling parrots hatch asynchronously and their growth rates can vary within sibling groups due to environmental factors and food availability (AWWP 2007). While there have been some studies that have documented growth rates in wild Australian and neotropical psittacine birds (Hammer *et al.,* 2005; Saunders, 1986; Renton, 2002, Navarro and Winkler, 1990) there are few published reports of the expected growth rates for hand-raised macaw (Smith, 1991). In this paper we present some important parameters that can be used as a comparative guide for the future captive breeding of the Spix's macaw. The growth rate curves obtained for Spix's macaw chicks were of a similar shape to those published for other macaw species (Smith, 1991). Chicks attained a maximum body weight of 360 g or approximately 20% larger than the final fledgling weight of 300 g. It is normal for many species, but particularly altricial nestlings, to attain maximum body weights that are much higher than those of adults. This presumably provides them with adequate reserves to cope with the energetically expensive final phase of primary flight feather development and their first days of flight.

Detailed analysis of the 2005 and 2006 hand rearing records indicate that the regurgitation episodes had minimal effect on the chick's growth rates. There was no pattern of regurgitation associated with temperature or humidity variations or with any particular feed formula. However, there was a peak

in regurgitation during the period when chicks are attaining their maximal body weight and thus entering a phase of less energy dependent development. Thus the regurgitation episodes may be primarily the result of over-feeding (meal volume overload).

Regurgitation in parrots is a non-specific clinical sign that may be associated with a multitude of definitive diagnoses including some potentially fatal diseases. Physiological regurgitation is common in birds that feed altricial young and the parent bird does this by pumping the neck in a way that returns food from the crop to the oral cavity. Careful observations indicated that physiological regurgitation is the common occurrence in the Spix's macaw chicks rather than an involuntary vomiting action. True vomiting from the glandular stomach is not possible in birds because they lack a diaphragm to rapidly increase abdominal pressure (Waltman and Beisenger, 1992). However the term vomiting is used to describe the expulsion of contents from the crop and or proventriculus from birds by a rapid, usually single, flicking action of the head and neck which can expel small amounts of vomitus a considerable distance away. Vomiting in birds is most often associated with primary alimentary tract lesions affecting the oesophagus, crop and or stomach.

An ideal temperature for rearing psittacine birds ranges from 36.6ºC at day 1, gradually decreasing to approximately 33ºC at 14 days of age to 28-24ºC by 29 days of age (Watson. R, 2007, pers.comm.,18th August, 2009). Humidity levels can vary markedly in a rearing room. A number of different psittacine species have been reared in the same nursery in previous years, all of which did not suffer from regurgitation episodes, even though similar variations in humidity presumably occurred throughout their rearing period.

The maintenance energy requirement is the amount of dietary metabolisable energy (ME) needed to support basal metabolism, as expressed by basal metabolic rate (BMR), plus additional energy to fuel activity and thermoregulation. The total energy requirements vary depending upon the environment, stage of life cycle and genetics of the individual. Knowledge of the energy requirements is very important because they are the primary factor that determines the amount of diet that should be fed or will be voluntarily consumed (Cambell and Lack, 1985). In a study of temperate parrots, it was concluded that the BMR of psittacine birds is dependant upon the thermal climate of the species' origin but is unrelated to feeding habits or water availability (Schoemaker *et al*., 1999). It is speculated that Spix's macaws were adapted to a dry environment in the wild, one of semi-desert habitat which provided, at best, a seasonal abundance of food (Jensen, S. 2006, pers.comm., 1st August). Therefore the Spix's macaw BMR may have been lower than what might be expected for a parrot of their size, allowing a lower food consumption level to suit the seasonal food abundance in the wild.

The energy requirements for chick growth are based upon the fractional growth rate of the species. Birds in the order Psittaciformes are among the slowest growing of altricial species (McNab and Salsibury 1995) and also develop endothermy at an earlier age (Bauck, 1995). Their energy requirements are likely to be similar to precocial species than to highly altricial species, which grow faster and thermoregulate later.

When provided *ad libitum* access to foods, birds generally eat an amount that satisfies their daily energy expenditure (Pearson, 1998). In the case of crop feeding psittacine birds, food is provided at certain time intervals and in a measured amount, which is common practice in rearing of psittacine birds. Determining if the bird is hungry and requires a feed is sometimes hard to analyse due to a learned behavioural response of vocalising and/or increased activity levels when a hand rearer is near. This can lead to individuals being fed a larger amount than required. In this instance, regurgitation

may occur; this is the most likely scenario with the captive population of Spix's macaws. Certain individual Spix's macaws may also fall into the habit of regurgitating after each feed which makes it harder to eliminate the problem; this is an area that requires further research.

Spix's macaw chicks 1, 2 and 3 were hand reared on Kaytee Exact Macaw hand feeding formula during the 2005/06 breeding season. Kaytee Exact Macaw hand feeding formula is specifically formulated for young Macaws, Eclectus, Hawk-headed and African grey parrots, or other birds requiring an increased energy diet. Communication with Ryan Watson (2006) has confirmed that the first three hand reared birds regurgitated daily and possibly at each feeding session. Unfortunately regurgitation data was not collected at regular intervals for chicks 1 and 2, therefore a comparison of regurgitation occurrences between the 2005 and 2006 birds can not be made accurately. It is confirmed that the 2006 birds reared on Nutribird hand rearing formula regurgitated less than the birds reared on Kaytee Exact Macaw hand feeding formula. This result emphasises that the higher fat and fiber content in Kaytee may be linked to increased regurgitation in the first three reared Macaws as well as the higher TDFI and higher maximum body weight. Kaytee Exact Macaw hand feeding formula is high in fat compared to both Nutribird A19 and A21 and is an ideal formula for the larger macaw species. Personal communication Ryan Watson (2006) has also suggested that Kaytee could be too rich for Spix's macaw during the middle and final trimesters of hand rearing; this is an area that requires further investigation.

A weight monitoring regime was conducted during 2005 for the adult Spix's macaw, which provided a clear indication that the Spix's macaw maintenance requirements were below the amounts anticipated for their size and in relation to what is consumed by other macaw species of similar size (Jensen, S. 2006, pers. comm., 1st August). Investigation into captive diets for species of similar size to the Spix's macaw, like the Red-bellied macaw *Orthopsittaca manilata,* which has an adult weight range between 280 and 350 grams (Collar, 1997), has proven difficult. Adult Spix's macaw captive weight range is 318 grams for males and 288 grams for females and they are offered a maintenance diet of 120 grams per day (AWWP records 2007). It is assumed that the Spix's macaw has a lower nutritional requirement than species of similar size but this area requires further investigation.

Currently the Spix's macaw weaning phase begins once they have reached 350 grams approximately. By feeding smaller feeds a maximum weight of approximately 350 grams could still be reached. This change in the rearing method may decrease or eliminate regurgitation episodes and a maximum weight could still be reached under the same 40 – 55 day time frame.

Bacterial infections of the alimentary tract due to *Escherichia coli (E coli), Pseudomonas* species and *Aeromonas* species are a common cause of alimentary tract disease, particularly in juvenile psittacine birds and neonates (Downs, 2000). Infections with *E coli, P aeruginosa, Klebsiella, Enterobacter* spp.*, Y enterocolitica* and *C freundii* have been diagnosed in a number of Spix's macaws from the sample group. Clinical signs of illness where not observed and a select few individuals underwent treatment for the infections.

Chicks 8, 9 and 10 were treated for Pseudomonas infections with Baytril at 15 mg/kg body weight for 5 days/ 2 times per day. Nystatin antifungal antibiotic was also administered at the same time as the baytril antibiotic at 0.03 mls/10g body weight for 10 days/ once daily. Some antibiotic and antifungal treatments have been known to cause regurgitation episodes in some avian species during the treatment period. Due to the fact that regurgitation occurrences were apparent before and after antibiotic or antifungal treatments, it is unlikely that the treatments were the causative agent for the regurgitation episodes amongst the Spix's macaws at AWWP.

Fungal infections such as candidiasis are frequently found in neonatal psittacine birds (Downs, 2000) but were relatively uncommon in macaw chicks. Candidiasis is primarily an upper intestinal tract disease that mainly affects the crop and oesophagus and is often secondary to other underlying diseases or malnutrition. Due to only four out of the ten birds testing positive to yeast infections, it is an unlikely cause for the regurgitation episodes seen in each individual chick. Considering that individuals tested negative to the infection after Nystatin treatment but continued regurgitating, also rules out *Candida albicans* as being the causative agent for the regurgitation episodes.

Birds may aspirate food during feeding or following regurgitation. Aspiration occurs most often in birds that are reluctant to feed or when food is introduced when there is no feeding response. Death from asphyxiation can occur if the bird inhales large amounts of food. It's not always possible to recognise aspiration in a bird, and later the bird may develop foreign body pneumonia. Poor weight gain, respiratory difficulty and persistently elevated white blood cell count indicates an aspiration effected bird (Girling, 2004). Younger birds will regurgitate if overfed and this can lead to aspiration pneumonia. Repeated regurgitation in a chick which is too young to wean, or regurgitation of large volumes may indicate disease or mechanical blockage (Ritchie *et al*., 1994).

Mild cases of aspiration were suspected occasionally during the hand rearing of the first two Spix's macaws bred at AWWP, mainly due to the chick's rapid onset of increased respiratory noises but these situations rapidly resolved. Investigation into possible occurrences of aerophagia (swallowing or gulping of air), goitre, crop impaction, stasis, crop burn or trauma by AWWP staff over the past two breeding seasons have eliminated the question of the regurgitation episodes being caused by the above.

Regurgitation is a major clinical presentation of PDD which is a debilitating wasting syndrome that was first described in the late 1970's (Flammer and Clubb, 1994). It has now been reported in more than fifty different psittacine species as well as in multiple families of birds suggesting it's cause is not restricted to any particular host (Clark, 1984). PDD has been reported more often in adult macaws than chicks (mean age 3.8 years; median age 2 years) (Gregory *et al* ., 1994), however characteristic microscopic changes have been noted in birds from twenty eight days to seventeen years. The ten individual Spix's macaws reared in 2005 and 2006 are currently in a very healthy status which lowers the possibility of PDD being the cause of the repeated regurgitation episodes. All recently reared birds have been isolated from all other individual Spix's macaw and other bird species. Strict quarantine procedures have been instituted for all movements in the breeding facility.

Lead and zinc toxicities are also commonly recognized as a cause of regurgitation in captive psittacine birds (Graham, 1991; Doneley, 1992) but are highly unlikely to cause problems in hand-raised birds fed commercial formulated diets. Clinical signs of heavy metal toxicity include regurgitation, diarrhoea, anorexia, polydipsia, and polyuria, dyspnea, depression, weakness, ataxia, seizures, weight loss and death (Van Sant, 1998). The daily behaviour of the Spix's macaws at AWWP are observed and monitored closely and there has been no evidence of adult birds chewing wires or other aviary furniture which could have resulted in a heavy metal toxicity poisoning. Regular health checks and blood testing has also failed to detect any evidence of heavy metal toxins. Regurgitation is a non-specific clinical sign with many different physiological and pathological causes. Medical reasons must be investigate when clinical signs of regurgitation affect the growth rate of hand-raised chicks. Detailed analysis of the 2005 and 2006 Spix's macaw hand rearing records have indicated that the regurgitation episodes were not associated with any evidence of a decline in growth rate and may well have been due to overfeeding during the period when the chicks initial rapid growth rate is declining. The two "outliers" Chicks 1 and 2 reached a maximum body weight much higher than the

remaining eight Spix's macaws despite episodes of regurgitation and the total daily food intake for the "outliers" was also much higher than the other eight individual birds. These results also coincide with the increased regurgitation episodes for the two 2005 reared birds. Since 2005, the rearing team at AWWP have been carefully monitoring the rearing methods which has lead to a gradual decrease in the total daily food intake and maximum body weights reached for the eight 2006 birds. Although regurgitation still occurred in the seven 2006 chicks the total number of occurrences have been steadily decreasing as the amount fed at each meal is revised and this has not interfered with chicks attaining a goal weaning weight of 350 g.

Whilst the 2006 chicks reared on Nutribird regurgitated less than the birds reared on Kaytee Exact Macaw hand feeding formula no firm association can be made between these products with the absence or occurrence of regurgitation episodes. Further investigation into this possibility is required. Nutribird^{Ò} A19 formula had been fed to the last three 2006 reared Spix's macaws for the first trimester. This method is still being assessed and due to an ongoing regurgitation syndrome in the Spix's macaw, it can be suggested that by feeding Nutribird^{Ò} A21 from the first trimester through to weaning may provide adequate nutritional requirements and may minimise regurgitation occurrences. Consistency in the hand rearing methods is essential for successful outcomes. Feeding A21 for the entire rearing duration may decrease regurgitation and provide continuity in the rearing methods. This proposed method will need to be analysed during the 2007 hand rearing season to assess its potential success in eliminating or lower the regurgitation episodes in the Spix's macaw.

In conclusion, hand-reared Spix's macaws require a lower total daily food intake during the hand rearing period than what has previously been believed. It has already been proven with individual Spix's macaw chicks 1 and 2 that by decreasing the maximum body weight, regurgitation occurrences can be reduced. By trialling a lower total daily food intake during the second rearing trimester, regurgitation episodes could be reduced if not eliminated from the future hand reared Spix's macaws at Al Wabra Wildlife Preservation.

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REFERENCES

Abramson J, Speer BL, Thomsen JB (1999). The Large Macaws; Their Care, Breeding and Conservation. Fort Bragg, USA: Raintree Publications. 230-234.

Alwabra Wildlife Preservation. http://awwp.alwabra.com. Accessed October 16, 2007.

Bauck L (1995). Nutritional problems in pet birds. *Semin Avian Exotic Pet Med.* **4**:3-8.

Bauck L, LaBonde J (1997). Toxic Diseases. In: Altman RB, Clubb SL, Dorrestein GM, Quesenberry K, eds. *Avian Medicine and Surgery*. Philadelphia, USA, Saunders. 604-613.

Cambell B, Lack E (1985). *A Dictionary of Birds*. The British Ornithologist Union.136.

Clark FD (1984). Proventricular Dilation Syndrome in large psittacine birds. *Avian Diseases.* **28**:813-815.

Collar NJ (1997). Family Psittacidae (Parrots). In: Hoyo JD, Elliot A, Sargatal J. eds. *Handbook of the Birds of the World.* Volume 4 - Sandgrouse to Cuckoo's. Barcelona, Spain. Lynx Editions:280-477.

Doneley R (1992). Zinc toxicity in caged and aviary birds – "new wire disease". *Aust Vet Practice*, **22**:6-11.

Downs CT (2000). Ingestion patterns and daily energy intake on a sugary diet: the Red lory *Eos bornea* and the Malachite sunbird *Nectarinia famosa. Ibis.* **142**:359-364.

Flammer K, Clubb SL (1994). Neonatology In: Ritchie BW, Harrison GJ, Harrison LR, ed. *Avian Medicine: Principles and Application.* Lake Worth, Florida, Wingers. 805-841.

Girling S (2004). Diseases of the digestive tract of Psittacine birds. *In Practice.* **26**:146-153.

Graham DL (1991). Wasting/proventricular dilation disease: a pathologist's view. *Proc Annu Conf Assoc Avian Vet.* 43-44.

Gregory CR, Latimer KS, Niagro FD, Ritchie BW, Campagnoli RP, Norton TM, McManamon R, Greenacre CB (1994). A Review of Proventricular diliation syndrome. *J Assoc Avian Vet.* **8**:69-75.

Hammer S, Gerlach H, Bürkle M, Schultz J (2005). Proventricular Dilation Disease (PDD) in Spix's Macaw *Cyanopsitta spixii*. In *International Symposium on Disease of Zoo and Wild Animals.* Prague, Czech Rebublic.

IUCN Red list of Threatened Species. www.iucnredlist.org Accessed October 16th 2007.

McNab BK, Salsibury CA (1995). Energetics of New Zealand's Temporate parrots. *NZ J Zool.* **22**:339-349.

Navarro JL, Winkler DW (1990). Growth of monk parrots. *Wilsons Bulletin.* **102**:520-525.

Pearson JT (1998). Development of thermoregulation and post hatching growth in the altricial cockatiel *Nymphicus hollandicus. Phys Zool.* **71**:237-244.

Renton K (2002). Influence of environmental variability on the growth of Lilac-crowned Parrot nestlings. *Ibis.***144**:331-339.

Ritchie BW, Harrison GJ, Harrison LR (1999). *Disease Etiologies. Section 5 – Bacteria.* In *Avian Medicine – Principles and Application.* Delray beach, Florida, HBD International Inc. 958.

Saunders DA (1986). Breeding season, nestling success and nestling growth in Carnaby's cockatoo, *Calyptorrhynchus funereus latirostris*, over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. *Aust Wildlife Res.* **13**:261-273.

Schoemaker NJ, Lumeij JT, Dorrestein GM, Beynen AC (1999). Diet-related problems in pet birds. *Tijdschr Diargeneeskd.* **124**:39-43.

Smith GT (1991). Breeding ecology of the western long-billed corella *Cacatua pastinator pastinator. Wildlife Research.* **18**:91-110.

Waltman JR, Beisenger SR (1992). Breeding behaviours of the green-rumped parrotlet. *Wilsons Bulletin.* **104**:65-84.

Van Sant F (1998). Zinc and parrots: more than you ever wanted to know. *Proc Annu Conf Assoc Avian Vet.* 305-313.

AL WABRA WILDLIFE PRESERVATION
Sheikh Saoud Bin Mohd. Bin Ali Al-Thani

Avian Nursery, Parrot Chick Feeding and Weight Records

Species: Spix's macaw Stocklist No : 5829 Name: Pixie Parents Stock List No : 4184 / 4269

Hatch Date: 23 / 10 / 2005 Hatch Time: 14:00 Hatch Weight: 12 grams Cage origin: B22-7

Comments: Hatched strongly, very vocal and active throughout the hatching process.

Date	Age	Time	Feed No.	Brooder Temp C	Brooder Hum %	Chick Wt B/F	Chick Wt A/F	Total Vol. Fed	% Solids	Formula Fed	General Comments / Treatment / Supplements (g/lrs/w) glucose, lactated ringers solution, water
	1	1600	1	36.5	68	11.9 g	12.1 g	0.2 g	0%	LRS/g/w	Very active and vocal, gave a good feed response.
		1730	2	36.7	70	12.0 g	12.3 g	0.3 g	0%	LRS/g/w	Strong feed response. Green faeces. Very vocal.
		1900	3	36.5	64	12.2 g	12.6 g	0.4 g	0%	LRS/g/w	Fed well. Crop nearly empty. Normal faeces. Vocal.
		2100	4	36.5	66	12.5 g	13.0 g	0.5 g	0%	LRS/g/w	Fed well. Crop empty. Normal faeces. Vocal.
		2230	5	36.5	72	12.7 g	13.2 g	0.5 g	0%	LRS/g/w	Fed well. Crop empty. Normal faeces. Vocal.
		2400	6	36.5	76	13.0 g	13.6 g	0.6 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.
							Total amount Fed		2.5 g		
	2	0530	1	36.2	76	13.0 g	13.5 g	0.5 g	100%	LRS/g/w	Less Vigorous. Crop empty.
		0635	2	36.2	76	13.3 g	13.8 g	0.5 g	10%	KT	Very active. Good feed response. Crop almost empty.
		0845	3	36.4	69	13.4 g	14.0 g	0.6 g	10%	KT + L	Fed well. Crop empty. Normal faeces. Vocal.
		1030	4	36.0	70	13.7 g	14.5 g	0.8 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.
		1230	5	36.0	70	13.8 g	14.8 g	1.0 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.
		1430	6	36.0	66	14.0 g	15.0 g	1.0 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.
		1645	7	36.0	70	14.3 g	15.6 g	1.3 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.
		1915	8	36.0	70	14.5 g	15.5 g	1.0 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.
		2215	9	35.8	74	14.4 g	15.6 g	1.2 g	10%	KT	Fed well. Crop empty. Normal faeces. Vocal.

Figure 1. Sample record-keeping sheet for an individual Spix's macaw chick showing 2 days' of body weight measurements and other data.

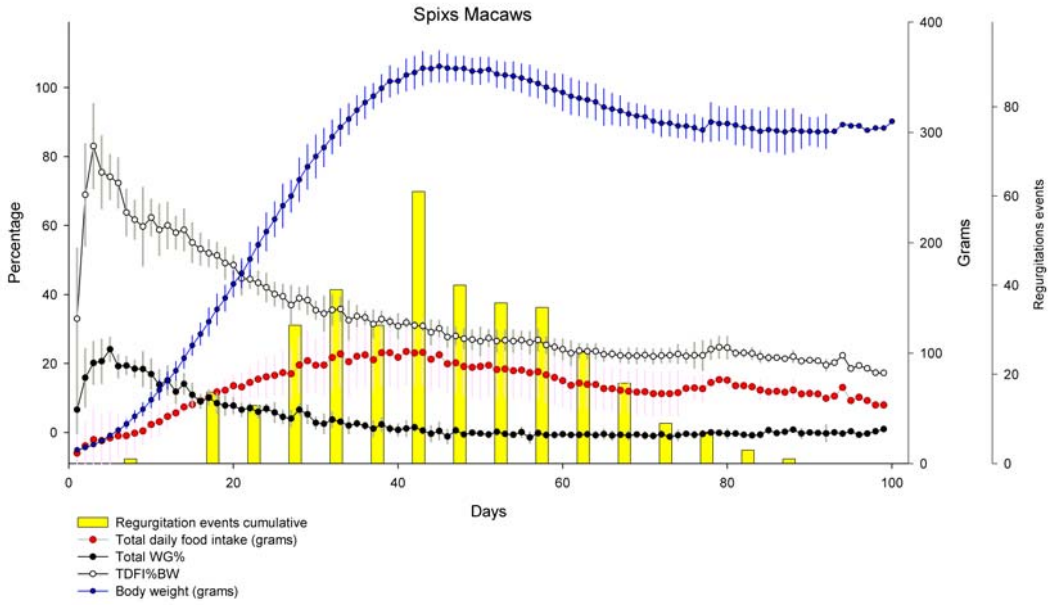

Figure 2. Growth rates of Spix's macaw chicks (n=8) demonstrating a peak in regurgitation at 42 days at the same time as chicks attained their maximum body weight of 360 g. The highest weight gains as a percentage of body weight occurred in the first 2 weeks (peak 24.1 ± 3.4 % at d ay 5) and the maximum daily food intake as a percentage of body weight gradually dropped from a maximum of 83.1 ± 12.2 % to 31.1 ± 1.1 % at age 42 days. Abbreviations: WG indicates weight gain; TDFI, Total daily food intake; BW, body weight.

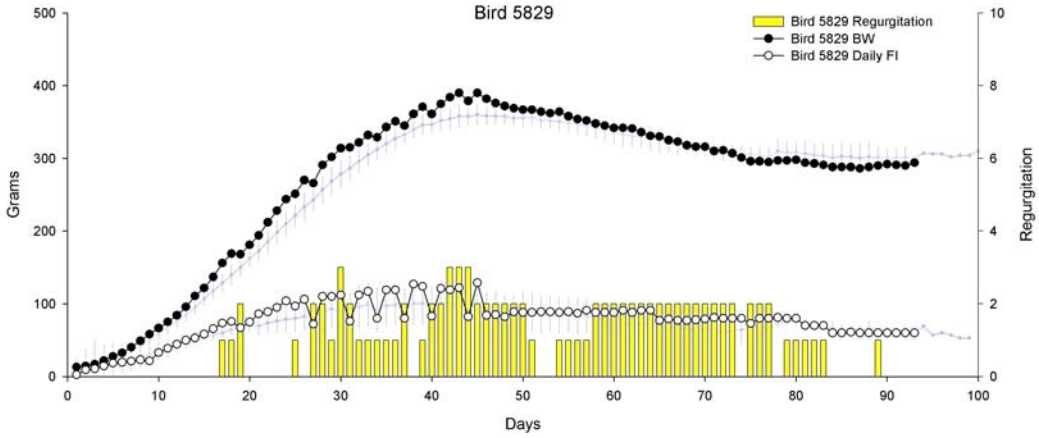

Figure 3. Growth rate of Spix's macaw chick 5829 demonstrating an attempt to minimise post-feeding regurgitation by reducing the daily food intake on alternating days between 25 and 45 days of age. Abbreviations: BW, body weight; FI, food intake.

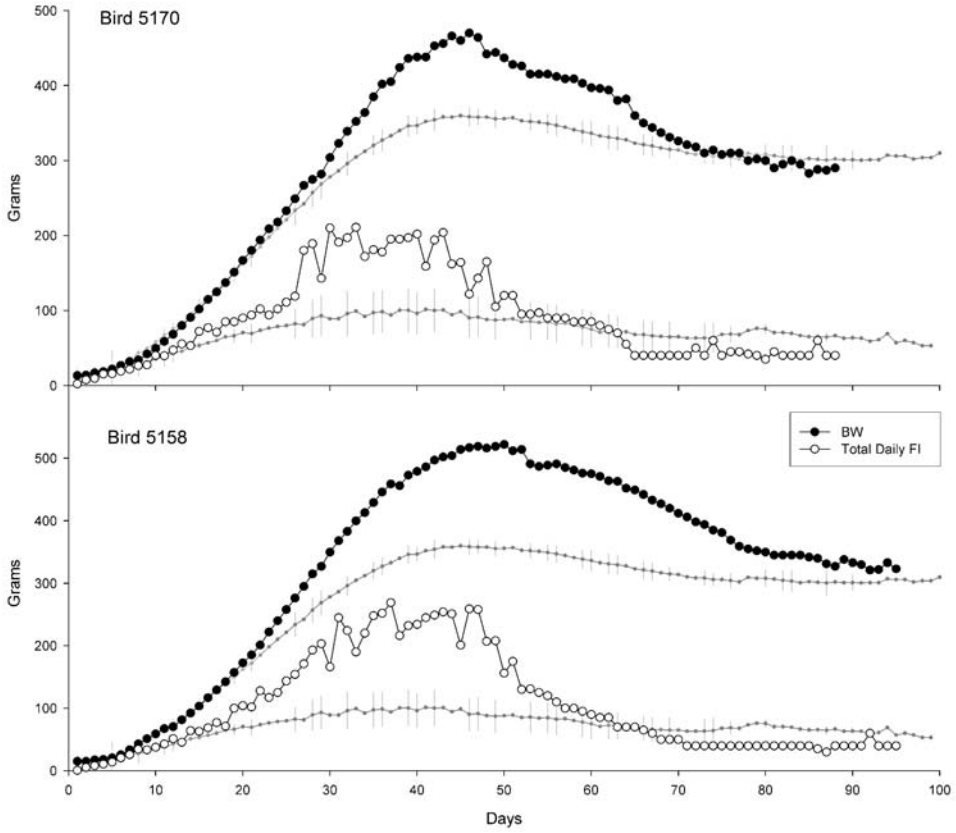

Figure 4. Growth records for two Spix's macaw chicks raised in 2005. Both birds experienced frequent post-feeding regurgitation episodes. Abbreviations: BW, body weight; FI, food intake.

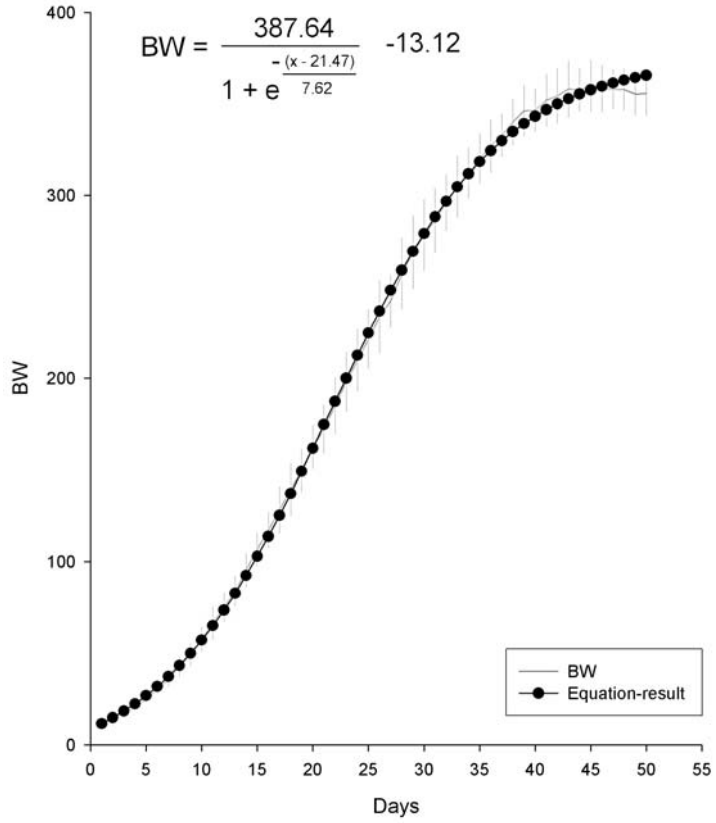

Figure 5. Logistic regression analysis of the growth rates of hand-raised Spix's macaw chicks (n=8) during their first 50 days of life. Abbreviations: BW, body weight.