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Abstract

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Evaluation of hand-rearing records for Spix’s macaw *Cyanopsitta spixii* at the Al Wabra Wildlife Preservation from 2005 to 2007

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*Right-hand running title:* AL WABRA WILDLIFE PRESERVATION: SPIX’S MACAW HAND-REARING RECORDS

*Left-hand running title:* THE DEVELOPING ZOO WORLD

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ABSTRACT
This investigation evaluates the feeding and growth of 14 Spix's macaw *Cyanopsitta spixii* at the Al Wabra Wildlife Preservation from 2005 to 2007. The follow-up period lasted for up to c. 6 months. The average weight of the chicks, the mean brooder temperature, the number of feedings per day, the formula fed, the ratio of the total amount fed per body weight and the number of regurgitating chicks per day were analyzed. Four different feeding strategies (differences in feeding formula and amount fed) are compared with regard to the weight gain. Group 2, Group 3 and Group 4 were fed more restrictively than Group 1 and, therefore, reached a lower peak weight although all four groups finally reached the same weight level around day 100. An association between non-restrictive feeding and number of regurgitations is suggested in the dataset. All chicks survived and were weaned successfully. The investigation indicates the importance of a restrictive feeding strategy and individual control.

Key-words: hand-rearing, growth, regurgitation, restrictive feeding, Spix's macaw, weight gain.

INTRODUCTION
Many bird species have become extremely rare in the wild. Breeding these species in captivity is, in many cases, a very important component for their conservation. In order to achieve a higher success rate in the breeding of rare species, hand-rearing may be adopted for a number of reasons: (1) to increase the production by encouraging a pair of birds to lay additional clutches, (2) to save sick or abandoned
offspring, (3) to prevent or reduce the transmission of diseases from the parents to the neonates, or (4) to raise offspring from artificially incubated eggs (Hanson, 1987; Ritchie et al., 1994; Deeming, 2002). In particular, the potential to increase a breeding population fast is a major incentive for hand-rearing in conservation programs. However, the breeding competence of hand-reared birds might be compromised (Myers et al., 1988), for example due to inappropriate choice of nest sites, and competence for survival in terms of predator avoidance and food acquisition might not be well-developed in hand-raised birds. Therefore, hand-rearing must be considered a first step (for increasing individual numbers) in a long series of measures that includes establishment of naturally breeding and rearing pairs, acclimatization to the release habitat, training, and post-release supplemental feeding – measure which have been proven crucial for the success of psittacine conservation efforts (Brightsmith et al., 2005; White et al., 2005).

The Spix’s macaw is thought to be already extinct in the wild and hence considered Critically Endangered (IUCN, 2008); therefore, great importance is placed on the breeding of this species in captivity. Historically, the reproduction success in captive Spix’s macaws has been inconsistent, and the captive population had a series of infectious disease problems (Watson et al., 2007). Therefore, in the initial stages of the breeding program, hand-rearing of hatched chicks was adopted to maintain the highest possible level of rearing success, and to reduce transmission of diseases from parents to offspring.
Hand-rearing must always take the nutritional requirements of the different species into account. **Macaws (Ara spp.)**, for example, are thought to need a higher fat content in their food than other Psittacines (Reinschmidt, 2000). Not only the formula and the feeding management but also environmental conditions have a profound impact on the health of the birds and, therefore, on the breeding success (Ritchie et al., 1994). For instance, the humidity in the brooder of macaws should never fall below 40% as they are especially susceptible to the toe-syndrome (swelling of one or more toes) (Reinschmidt, 2000; Speer 2007).

Groffen et al. (2008) published an exact description of hand-rearing strategy of Spix’s macaw from 2005 to 2006 at AWWP with special regard to regurgitation episodes. Here we expand this analysis to 2007 with special emphasis on weight gain and feeding. Besides the description of the measured values, four different feeding strategies are compared with regard to the weight gain and the occurrence of regurgitation.

**MATERIALS AND METHODS**

At AWWP Spix’s macaw chicks were hand-reared primarily for bio-security reasons and because the parent birds had no chick-rearing experience. From 2005 to 2007, 14 Spix’s macaw chicks were hand-reared at AWWP, of which all survived. Apart from the feeding protocol, all were hand-reared using the same procedures. For further details on procedures see Groffen et al. (2008).

**Brooders**
Eggs were removed from nests 23 days after being laid and replaced by dummies if the bird was not yet used to egg removal. After hatching the chicks stayed in a brooder for c. 35–40 days, where temperature and humidity was controlled and monitored, before being moved to a larger brooder at room temperature. The initial temperature in the brooder where the chicks were kept after hatching was c. 37°C. Following a common practice in parrot breeding (Hansen, 1987; Reinschmidt, 2000), the temperature was lowered c. 0.5°C each day to c. 26.5°C until c. 40 days after hatching. It was then kept constant for the next 20 days and then lowered another 1°C. The conditions for the last four chicks reared in 2007 were slightly different. The temperature was lowered to 26°C (except 28°C for the Spix’s macaw ID no. 7195) c. day 50–60 and then raised again to 32–33°C to acclimatize the birds to the hot temperatures they would experience when they left the nursery. Humidity averaged 55% but ranged from 24 to 76%.

Feeding/weighing
Each time chicks were fed, they were weighed before and after feeding using a Kern scale (Kern-440.33N, 0.01–200 g; Kern-Cm60-2, 0.01–60 g; Kern-EMB 200-1, 0.1–200 g; Kern 440-53, 1–6000 g). For this study, only the first weight measured in the morning before feeding was taken into account.

Different formulas were fed to the Spix’s macaws: Kaytee Macaw Exact Hand Feeding Formula, Nutribird A19 and A21 hand-rearing formulae (Table 1). The chicks bred in 2005 and 2006 were crop fed using a syringe with a short piece of medical-grade silicon
tubing attached. The amount fed was individually adjusted by the caretaker to the capacity and filling state of the crop; in particular, distension of the crop beyond what was considered “normal” was avoided. The chicks bred in 2007 were fed via a syringe to the beak and were allowed to dictate food intake (Table 2). Especially for the 12 last chicks, the goal was to feed more restrictively than in the previous 2 years.

On the first day all chicks received Lactated Ringer solution, glucose and filtered water and at least one solid feeding at night (unless they did not hatch until late at night). With their first feed they also were given a Lactobacillus strain (developed at the Institute for Avian Disease, University of Munich) cultured at the AWWP and then given occasionally throughout the rearing period. The last four chicks reared in 2007 received PT12® (Lactobacillus salivarius, RE-SCHA) every four days up to the age of c. 17 days and then again once a day for days 57–71. After the initial fluid feeds, the chicks were introduced to the formula which was mixed at a ratio of 10% hand-rearing food:90% water, and warmed to a temperature of 40–44°C for young chicks up to the age of 80 days and 36–40°C for older ones.

Out of the 14 Spix’s macaws in this study the first three chicks (Group 1) were fed with Kaytee Macaw Exact Hand Feeding Formula (KT). The first four chicks from 2006 (Group 2) received Nutribird hand-rearing formula A21 from day 1 until weaning. The next three chicks from 2006 (Group 3) were fed Nutribird A19 from the day they hatched until they were c. 23 days old (±4.6) and then were fed Nutribird A21 until they were weaned. The four chicks from 2007 (Group 4) were fed
with Nutribird A21 until day 99 (±1.5) and then with Nutribird A19 until weaned at the age of 120 days (±2). Additionally, Group 4 received apple baby food and mixed-vegetable baby food added to their formula from day 26 (±4.5) until they were weaned (each baby food added at 10% of the total diet weight). Three (6359 – Group 3, day 101-108; 6299 – Group 2, day 124-156; 6293 – Group 2, day 130-138) of the eleven chicks fed with Nutribird were changed to KT until they were totally weaned. Spix’s macaw ID no. 7195 was parent-reared for the first 9 days but had to be removed from the nest for hand-rearing after parental neglect. This chick showed more health problems than the others, had poorer weight gain and was slow to wean (167 days).

**Weaning**

The weaning phase began once the chicks peaked in weight at c. 350 g and they became completely independent between 100 and 150 days old. Weaning is considered the most delicate part of hand-rearing. The chicks started using solid food as a play item from c. 55 days of age. Eventually they would swallow the food and hand feeding was tapered off. During weaning, the chicks were brought together in a free-flight enclosure to socialize and encourage each other to eat solid foods.

**Health**

Cloacal and oral swabs were taken for bacteriological examinations on day 3 and day 7, and from then on a weekly basis until weaning. Faecal samples were obtained weekly. As soon as a chick showed any signs of illness, a veterinarian was consulted and appropriate treatment was initiated.
To prevent problems with the digestion it is recommended that the chicks are supplied with *Lactobacillus* right from the beginning (Reinschmidt, 2000). Parent-reared chicks receive these bacteria and digestive enzymes that are needed for digestion of food and a healthy gut flora through the crop contents of the parents (Künne, 2000). *Lactobacillus* strains are commercially available (Künne, 2000). Al Wabra Wildlife Preservation produces additionally a *Lactobacillus* strain (developed at the Institute for Avian Disease, University of Munich, Munich, Germany) which is utilized in hand-rearing Spix’s macaws.

**RESULTS**

**Weight**

Body weight development showed the pattern typical for handfed psittacines (Clubb et al., 1992b): At first, the weight increased in a sigmoid curve until the weight peak (Group 1: 460 g on day 46; Group 2: 359 g on day 52; Group 3: 348 g on day 50; Group 4: 351 g on day 47). It then decreased gradually over the next 50 days until levelling out at the normal weight of adult captive Spix’s macaws [318 ± 30 g for males, \( n=20 \); 288 ± 38 g for females, \( n=30 \) (AWWP written records, August 2006)] (Fig. 1a).

**Feeding**

The total amount fed was increased gradually over the first days, reaching the peak at c. 40 days after hatching; then, it was reduced again until the chicks were weaned (Fig. 1b). The chicks were fed a high percentage of their own body weight in the first week with several being fed more than 80% (Fig. 1c).
Health

Many of the Spix’s macaws hand-reared at AWWP showed irregular regurgitation after feeding. Regurgitation was observed from day 9 to 90. Most of the chicks regurgitated between 30 to 70 days of age (Fig. 2). For the first two chicks reared in 2005, the records of regurgitation events were incomplete, but staff notes indicate that these two chicks regurgitated daily even during the early hand-rearing period. Apart from the regurgitation problem there were no cases of gastrointestinal diseases, blockages or compression. From the swab samples various bacteria were diagnosed in a number of Spix’s macaws such as Escherichia coli, Pseudomonas aeruginosa, Klebsiella spp, Enterobacter spp, Yersinia enterocolitica and Citrobacter freundii. Some of the chicks (ID nos: 5829, 6200, 6299, 6347, 6353, 6359, 7100, 7097, 7195) showed respiratory signs (sneezing, nasal discharge and heavy breathing) for a short period. The signs disappeared with antibiotic (enrofloxacin, 15 mg/kg by mouth, twice a day for 5 days) and antifungal (nystatin, 3000 international units/10 g, by mouth once a day for 10 days) treatment (Hammer & Jensen 2005).

DISCUSSION

Weight

According to literature (Ritchie et al., 1994) the growth rate of psittacines may be as high as 17% a day during the first week. Psittacine growth curves usually contain a period of negative growth after a peak body mass that surpasses final adult body mass (Hanson, 1987; Clubb et al., 1992b) – this pattern is shared by many bird species, and traditional sigmoidal growth curves are
therefore considered not ideal to describe the body mass development of birds, because they do not reflect this period of negative growth (Brown et al., 2007). Our observations showed that the Spix’s macaws reared at AWWP increased their weight even up to 23.5% per day during the first week. On average, the chicks did not drop under 10% weight gain per day until day 16. Thus the chicks multiply their weight approximately by three during the first week (Group 1: x3.0; Group 2: x2.9; Group 3: x3.4; Group 4: x3.1). According to Reinschmidt (2000) chicks should at least double their weight within the first week.

In psittacines it is normal that the maximum weight that is reached after two-thirds of the nesting period is higher than the adult weight (Clubb et al., 1992b). The maximum body mass is usually reached between 7-9 weeks in cockatoos and psittacines (Clubb et al., 1992b), and with the peak occurring at 55 days of age, the Spix’s macaws of this study match the general pattern. During weaning, weight loss occurs of about 10-20% (Hanson, 1987; Clubb et al., 1992a; Reinschmidt, 2000; Masello & Quillfeldt, 2002). The causes of the phenomenon still remain to be investigated (Masello & Quillfeldt, 2002), and a comparative evaluation of the proportional weight loss in different avian species is, to our knowledge, lacking so far. Recommendations therefore appear devoid of a scientific basis, yet still provide empirical guidelines. Reinschmidt (2000) warns that a weight loss during weaning of more than 20% indicates a problem and that in this case the amount of food given should be increased. In Group 1 the birds reached the highest maximum weight but ended up on the same weight
level as the other three groups after weaning. Therefore, they showed a higher weight loss of up to 40.2% (Table 3). We do not interpret this as an alarming loss of weight but suggest it is the consequence of the excessive maximum weight. Possible reasons are the higher hatching weight, a less restrictive feeding strategy and the higher fat content of the Kaytee Macaw Exact Hand Feeding Formula (Table 1). We therefore support the opinion of Groffen et al. (2008) that the concept that macaws need a higher fat content than other parrots (Reinschmidt, 2000) does not apply to the Spix’s macaw (which is not a true macaw, anyhow, but more closely related to the Aratinga group; Miyaki et al., 1998).

Considering the discussed points the feeding strategy of Group 3 resulted in the most homogeneous weight development and a weight loss of around 21% (Table 3), which is closest to the recommended value (Reinschmidt, 2000). The strategies used in Group 2 and Group 4 also proved better than the one used for Group 1, because birds in Group 2 and Group 4 also demonstrated a lower peak weight. However, their values were less uniform than those from Group 3.

Additionally, it should be taken into account that growth rates among parrots differ between hand-reared, and parent-raised captive birds, and between free-ranging (parent-reared) birds (Abramson et al., 1995; Wolf & Kamphues, 2003). Wolf & Kamphues (2003) observed lower body masses in hand-reared lovebirds (Agapornis spp) during the first 26 days of life before reaching the same weight as the parent-reared birds.
**Feeding/methods**
In parrot chicks, with each feeding usually about 10% (as-fed basis) of the body weight of the chick is fed (Reinschmidt, 2000; Speer, 2007), but the actual amount may differ with the experience and attitude of the caretaker. With a decline from 10 daily feedings to 2, the total amount fed per day decreased correspondingly from about 90% to 20% in the Spix’s macaws (Fig. 1c).
Several authors remark on the filling state of the crop. Reinschmidt (2000) is of the opinion that the crop should be empty before the next feeding or should at least not contain more than 20% of the last feeding. Ritchie *et al.* (1994) and Künne (2000) on the other hand stress the importance of letting the crop empty completely at least once a day to prevent decay of food in the crop. At AWWP no feedings were left out as there were no problems with the filling state of the crop (was empty or almost empty most of the time).

**Health/regurgitation**
Regurgitation often occurs in hand-reared psittacines. It can be caused by bacterial and mycotic food contamination, inadequate food temperature (too hot or too cold), inappropriate amount of food or feeding interval, inappropriate food consistence (thickening in the crop), foreign bodies (especially nesting material), stress, candidiasis, and use of some drugs such as trimethoprim-sulfa compounds and doxycycline (Pees *et al.*, 2004). Furthermore, careless handling of chicks with food in the crop can lead to regurgitation and aspiration (Ritchie *et al.*, 1994). However, the probably most common reason for regurgitation in hand-reared parrot chicks is excessive feeding. Based on the
observation that parent-raised birds usually grow faster than hand-raised birds, Hanson (1987) warned that “probably the most common error made in handrearing parrot chicks is not feeding enough”, and the fear of “not feeding enough” may induce caretakers to feed too much.

The occurrence of regurgitation decreased over time from each feeding regime to the next (Figs 2 and 4). Groffen et al. (2008) noticed that the frequency of regurgitation occurrences increased as the total daily food intake reached its maximum. This was also the time when most individuals reached their maximum weight. We can confirm this in our study (Fig. 2) with the notable exception of Group 4, which regurgitated most before the animals had reached their maximum weight (Fig. 2d). As the chicks showed no signs of illness that could have led to regurgitation, we agree with Groffen et al. (2008) that the weight excess and the large amount of food per feeding were responsible for these regurgitation incidents. Neither the temperature nor the humidity in the nursery room showed an impact on the regurgitation episodes (Groffen et al., 2008). As several other bird species have been hand-reared in the same facilities with no problems of regurgitation an environmental factor can be excluded (Groffen et al., 2008).

Nevertheless, it is difficult to identify a threshold or a recommendation in the present data. Reinschmidt (2000) suggests that if more than 12% of the body weight is given in a single feeding, regurgitation may occur. In the Spix’s macaws, considerably higher amounts were given during the wirst week of life without
regurgitation, and later, regurgitation occurred even though the amount given during one feeding did not exceed 10%. The outstanding pattern in the relationship between feeding and regurgitation is that regurgitation occurs after the initial feeding peak at days 2-5 (when expressed as % of body weight), and that it appears to be linked to the decline in feeding (in % of body weight), with a faster decline preventing regurgitation (Fig. 3). However, more data is needed to decide whether a faster decline in the amount fed (% body weight) can really prevent regurgitation. Considering the regurgitation, the feeding protocol used in Group 4 appears to be the best, but the consistent reduction of regurgitation over the feeding regimes suggests that an even further reduction of the incidence of regurgitation is possible if food is offered in a more restricted manner.

It was noticeable that the birds reared on Nutribird hand-rearing formula (Groups 2–4) regurgitated less than the birds reared on Kaytee Exact Macaw hand-feeding formula. Compared to Nutribird hand-rearing formula, Kaytee Exact Macaw formula does not mix consistently but separates and then tends to settle at the bottom of the mixing dish. This can cause problems with younger chicks as the solid component can often settle in the crop whilst the liquid is absorbed. Nutribird on the other hand does not harden in the crop and will stay consistent once prepared. This aspect is another reason to prefer the last three feeding protocols over the first.

CONCLUSIONS
The important role of the restrictive feeding must be emphasized. In contrast to other macaws hand-reared at AWWP, a strictly controlled feeding strategy is crucial in hand-rearing the Spix’s macaws and contributes to the healthy development of the chicks. Al Wabra Wildlife Preservation will follow the described protocol for Group 4 in principle as it appears to offer the safest route forward for the successful hand-rearing of the Spix’s macaw and, therefore, a step into the direction of breeding this species with the goal of a future reintroduction into the wild.

ACKNOWLEDGEMENTS
We thank H.E. Sheikh Saoud Bin Mohamed Bin Ali Al-Thani for his kind support of the Zoo Research Camp (ZRC) 2007, which was realized by AWWP and the Clinic of Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich. The ZRC 2007 was also financially supported by the Vetsuisse Faculty and the Society of Swiss Veterinarians. We thank the staff of the Bird Department at AWWP who hand-reared the birds and collected the data.

PRODUCTS MENTIONED IN THE TEXT

**Hero Baby®:** baby food, flavours Mixed Vegetables and Apple, manufactured by Hero España, E-30820 Alcantarilla (MU), Spain.

**Enrofloxacin (Baytril 0,5% oral solution®):** fluoroquinolone antibiotic, manufactured by Bayer Vital GmbH, 51368 Leverkusen, Germany.
Kaytee Macaw Exact Hand Feeding Formula®:
macaw diet, manufactured by Kaytee Products Inc, Chilton, WI, USA.


Lactated Ringer’s solution (Ringer-Lactat nach Hartmann B.Braun®): isotonic fluid, manufactured by B.Braun Melsungen AG, 34209 Melsungen, Germany.

Lactobacillus: bacteria strain, developed at the Institute for Avian Disease, University of Munich, Munich, Germany.


Nystatin (Nystatin Albrecht ®): antifungal treatment, manufactured by Albrecht GmbH, 88326 Aulendorf, Germany.

PT12®: Lactobacillus salivarius strain, manufactured by RE-SCHA, 33142 Büren, Germany.

REFERENCES


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<tr>
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After hatching feedings every 2 hours from 0600 hours until 1200 hours, as many as ten times per day. Day 2–4 decrease to six feedings per day. Day 5 (±1.2)–6 (±1.0) five feedings per day. Day 7–24 (±4.9) four feedings per day. Day 25–55 (±12.1) three feedings per day. Day 56–101 (±12.8) two feedings per day. Day 100–weaning one feed per day. Weaning 124 days (±13.7) after hatching.

<table>
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<th>AGE</th>
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<td>After hatching</td>
<td>feedings every 2 hours from 0600 hours until 1200 hours, as many as ten times per day.</td>
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<td>Day 2–4</td>
<td>decrease to six feedings per day</td>
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<td>Day 5 (±1.2)–6 (±1.0)</td>
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<td>Day 7–24 (±4.9)</td>
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<td>Day 100–weaning</td>
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<tr>
<td>Weaning</td>
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Table 2. The feeding regime for hand-rearing Spix’s macaw *Cyanopsitta spixii* hatchlings at Al Wabra Wildlife Preservation.
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Table 3. Percentage of weight loss during weaning of the 14 hand-reared Spix’s macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007: \(a\) bird 7195 was parent-reared for the first 9 days and therefore had a delayed weight development and reached a lower weight peak.

CAPTIONS

Fig. 1. (a) Average weights of the four groups (Group 1 n=3; Group 2 n=4; Group 3 n=3; Group 4 n=4); (b) average of total amount fed per day; (c) mean percentage of total amount fed in relation to the weight of hand-reared Spix’s macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007. Note the difference between Group 1 and the other groups between 20 and 50 days of age in (c).

Fig. 2. Average weight and regurgitation of the 14 hand-reared Spix’s macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007. Note that the number of regurgitating chicks decreases from one group to the next.

Fig. 5 Association between the average amount fed per day with the percentage of regurgitating chicks of four groups of hand-reared Spix’s macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007. Note that regurgitation mostly occurred when higher amounts were fed.
Figure 1
Figure 2
Figure 3