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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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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 analysed. 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 the number of regurgitations is suggested in the data set. All chicks survived and were weaned successfully. The investigation indicates the importance of a restrictive feeding strategy and individual control.

Key-words: growth; hand rearing; 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 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 quickly is a major incentive for hand rearing in conservation programmes. However, the breeding competence of hand-reared birds might be compromised (Myers *et al*., 1988) (e.g. inappropriate choice of nest sites) and their ability to survive, in terms of predator avoidance and food acquisition, might not be well developed. Therefore, hand rearing must be considered as a first step (for increasing individual numbers) in a long series of measures, including establishment of naturally breeding and rearing pairs, acclimatization to the release habitat, training and post-release supplemental feeding, all of which have been proven crucial for the success of psittacine conservation efforts (Brightsmith *et al*., 2005; White *et al*., 2005).

The Spix's macaw *Cyanopsitta spixii* is thought to be 'extinct in the wild' already and is 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 a series of infectious-disease problems has occurred in the captive population (Watson *et al*., 2007). Therefore, in the initial stages of the breeding programme, 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 different species into account. For example, macaws (*Ara* spp) 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 a brooder for 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 the hand-rearing strategy for Spix's macaw from 2005 to 2006 at the Al Wabra Wildlife Preservation (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 have no chick-rearing experience. From 2005 to 2007, 14 Spix's macaw chicks were hand reared at AWWP, all of which survived. Apart from the feeding protocol, all were hand reared using the same procedures. For further details on the procedures see Groffen *et al*. (2008).

Brooders

Eggs were removed from the 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 were 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 the common practice in parrot breeding (Hanson, 1987; Reinschmidt, 2000), the temperature was lowered *c*. 0 · 5 °C each day to *c*. 26 · 5 °C until *c*. 40 days after hatching. From 40 days onwards, temperature was 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) (at *c*. days 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 the 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 formulae 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 to

	% OF PRODUCT (BEFORE DILUTION)		
NUTRITIONAL VALUE	KT	A19	A21
Crude protein	19	19	21
Crude fat	13	12	8
Crude fibre	5	3	3
Crude ash	7	6	6

Table 1. Hand-rearing formulas given to Spix's macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007: KT, Kaytee Macaw Exact Hand Feeding Formula; A19, Nutribird A19; A21, Nutribird A21.

each bird was 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 last 12 chicks, the goal was to feed more restrictively than in the previous 2 years.

On the first day, all chicks received Lactated Ringer's solution, glucose and filtered water and at least one solid feed 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, Germany) 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 4 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 chicks.

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 (Hero Baby®) added to their formula (each baby food added at 10% of the total diet weight) from day 26 (± 4 · 5) until they were weaned. Three (ID no. 6359 – Group 3, days 101–108; ID no. 6299 – Group 2, days 124–156; ID no. 6293 – Group 2, days 130–138) of the 11 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).

AGE	NUMBER OF FEEDS
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 2. The feeding regime for hand-rearing Spix's macaw *Cyanopsitta spixii* hatchlings at Al Wabra Wildlife Preservation.

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 days 3 and 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 digestion, it is recommended that the chicks are supplied with *Lactobacillus* from the start (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). AWWP produces a *Lactobacillus* strain (developed at the Institute for Avian Disease, University of Munich, Germany), which was utilized in the hand-rearing Spix's macaws.

RESULTS

Weight

Body-weight development showed the pattern typical for hand-fed psittacines (Clubb, Skidmore *et al*., 1992). At first, 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 ♂♂, $n = 20$; 288 ± 38 g for ♀♀, $n = 30$ (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 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 $> 80\%$ (Fig. 1c).

Health

Many of the Spix's macaws hand reared at AWWP showed irregular regurgitation after feeding. Regurgitation was observed from days 9 to 90. Most of the chicks regurgitated between 30 and 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, such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella* spp, *Enterobacter* spp, *Yersinia enterocolitica* and *Citrobacter freundii*, were diagnosed in a number of Spix's macaws. Some of the chicks (ID nos: 5829, 6200, 6299, 6347, 6353, 6359, 7100, 7097 and 7195) showed respiratory signs (sneezing, nasal discharge and heavy breathing) for a short period. The signs disappeared with antibiotic (enrofloxacin, 15 mg kg^{-1} by mouth, twice a day for 5 days) and antifungal (nystatin, 3000 IU/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, Skidmore *et al*., 1992). This pattern is shared by many bird species and traditional sigmoidal growth curves are, therefore, not considered as 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 up to $23 \cdot 5\%$ 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: $\times 3 \cdot 0$; Group 2: $\times 2 \cdot 9$; Group 3: $\times 3 \cdot 4$; Group 4: $\times 3 \cdot 1$). According to Reinschmidt (2000), chicks should at least double their weight within the first week.

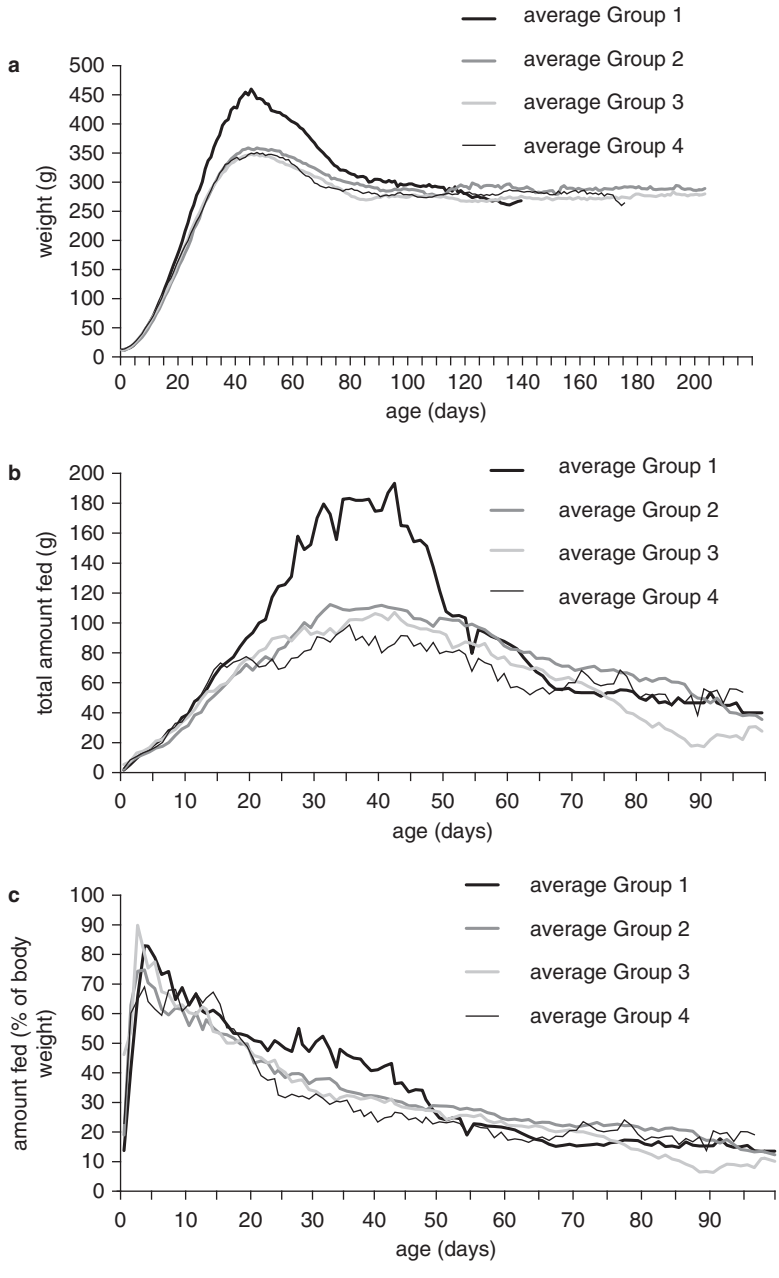

Fig. 1. (a) Average weights, (b) average of total amount fed per day and (c) mean percentage of the total amount fed (in relation to body weight), for four groups (Group 1, $n = 3$; Group 2, $n = 4$; Group 3, $n = 3$; Group 4, $n = 4$) of hand-reared Spix's macaw *Cyanopsitta spixii* at Al Wabra Wildlife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

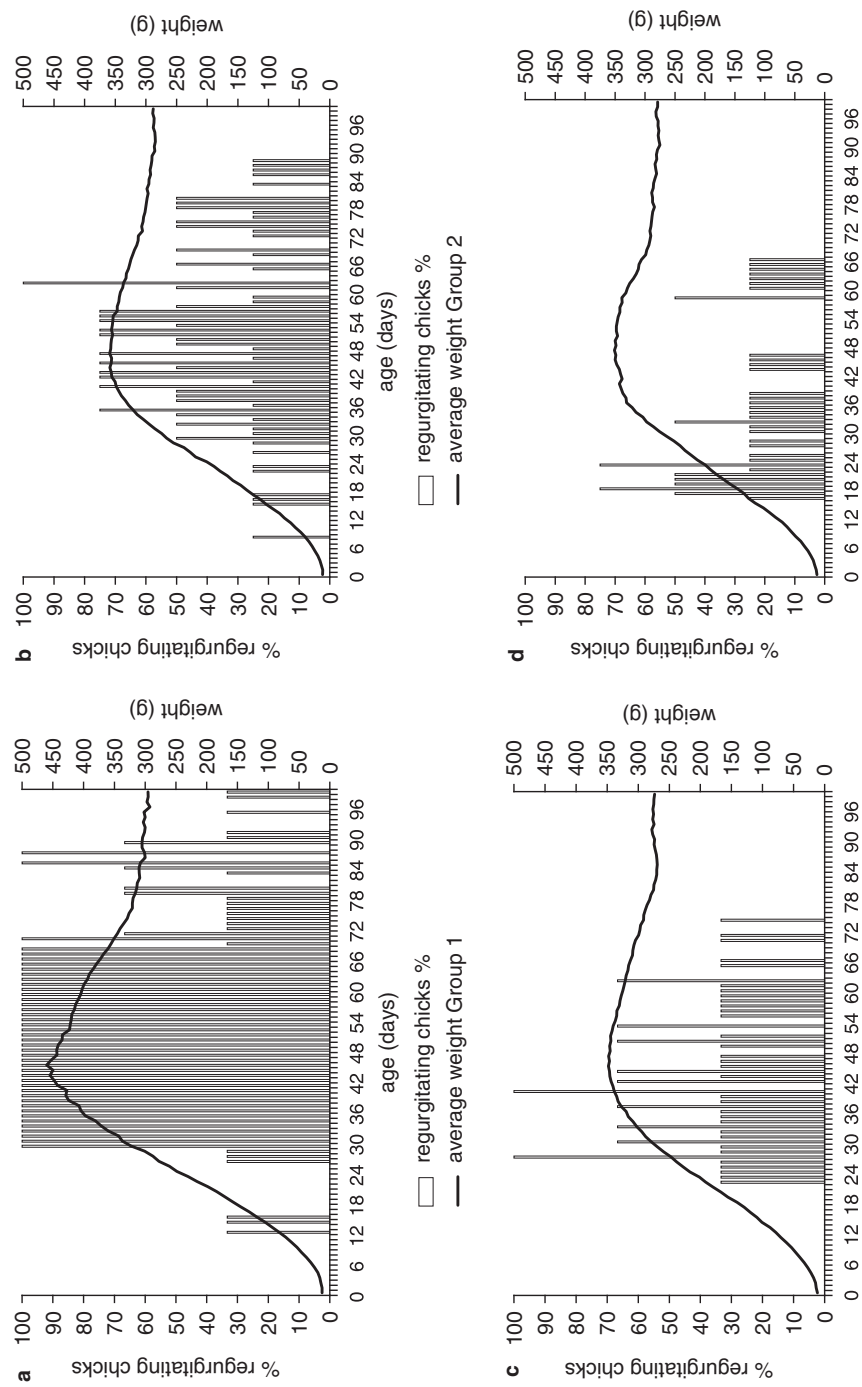

Fig. 2. Average weight and regurgitation for 14 hand-reared Spix's macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007: (a) Group 1, $n = 3$; (b) Group 2, $n = 4$; (c) Group 3, $n = 3$; (d) Group 4, $n = 4$. Note that the percentage of regurgitating chicks decreases from one group to the next.

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, Skidmore *et al*., 1992). The maximum body mass is usually reached between 7 and 9 weeks in cockatoos and psittacines (Clubb, Skidmore *et al*., 1992), and with the peak occurring at 55 days of age, the Spix's macaws in this study match the general pattern. During weaning, weight loss of *c*. 10–20% occurs (Hanson, 1987; Clubb, Clubb *et al*., 1992; Reinschmidt, 2000; Masello & Quillfeldt, 2002). The causes of this phenomenon 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 to be devoid of a scientific basis, yet still provide empirical guidelines. Reinschmidt (2000) warns that a weight loss of $>20\%$ during weaning 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 $40 \cdot 2\%$ (Table 3). We do not interpret this as an alarming loss of weight but suggest it is the consequence of an 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 of macaws needing a higher fat content than other parrots (Reinschmidt, 2000) does not apply to the Spix's macaw, which is not a true macaw but more closely related to the *Aratinga* group (Miyaki *et al*., 1998).

Considering these points of discussion, 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.

BIRD ID	SEX	MAXIMUM WEIGHT (G)	WEIGHT AT DAY 100 (G)	WEIGHT LOSS (%)
GROUP 1				
5158	♀	522	318	39 · 1
5170	♀	470	281	40 · 2
5829	♀	393	287	26 · 4
GROUP 2				
6200	♀	364	282	22 · 7
6212	♂	379	310	17 · 6
6293	♂	359	286	20 · 3
6299	♀	347	247	21 · 0
GROUP 3				
6347	♀	352	276	21 · 6
6353	♀	341	269	21 · 1
6359	♀	352	276	21 · 6
GROUP 4				
7097	♂	371	296	20 · 2
7100	♀	345	269	22 · 0
7107	♀	357	276	22 · 7
7195	♀	339	274	19 · 2[a]

Table 3. Percentage of weight loss during weaning of 14 hand-reared Spix's macaw *Cyanopsitta spixii* at Al Wabra Wildlife Preservation, 2005–2007: [a] bird ID no. 7195 was parent-reared for the first 9 days and, therefore, had a delayed weight development and reached a lower weight peak.

Additionally, it should be taken into account that growth rates among parrots differ between hand-reared and parent-reared 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

For parrot chicks, each feed is usually *c*. 10% (as-fed basis) of the body weight of the chick (Reinschmidt, 2000; Speer, 2007) but the actual amount may differ with the experience and attitude of the caretaker. With a decline from ten daily feeds to two, the total amount

fed per day decreased correspondingly from *c*. 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 feed or should at least not contain >20% of the last feed. Ritchie *et al*. (1994) and Künne (2000), on the other hand, stresses the importance of letting the crop empty completely at least once a day to prevent decay of food in the crop. At AWWP, no feeds were omitted as there were no problems with the filling state of the crop, which 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 consistency (thickening in the crop), foreign bodies (especially nesting material), stress, candidiasis and the use of some drugs, such as trimethoprim–sulpha 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, probably the most common reason for regurgitation in hand-reared parrot chicks is excessive feeding. Based on the observation that parent-reared birds usually grow faster than hand-reared birds, Hanson (1987) warned that 'probably the most common error made in hand-rearing parrot chicks is not feeding enough' and concern about 'not feeding enough' to chicks may induce caretakers to feed too much.

The occurrence of regurgitation decreased over time from each feeding regime to the next (Figs 2 and 3). 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 given per feed 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). Environmental factors can also be excluded as causes for the regurgitation, as several other bird species have been hand reared in the same facilities with no problems (Groffen *et al*., 2008).

Nevertheless, it is difficult to identify a threshold or a recommendation in the present data. Reinschmidt (2000) suggests that if >12% of the body weight is given in a single feed, regurgitation may occur. In the Spix's macaws, considerably higher amounts were given during the first week of life without regurgitation, and later regurgitation occurred even though the amount given during one feed 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 are 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 Macaw Exact Hand-Feeding Formula®. Compared with Nutribird hand-rearing formula, Kaytee Macaw Exact Hand-Feeding Formula® does not mix consistently but separates and then tends to settle at the bottom of the mixing dish. This can cause

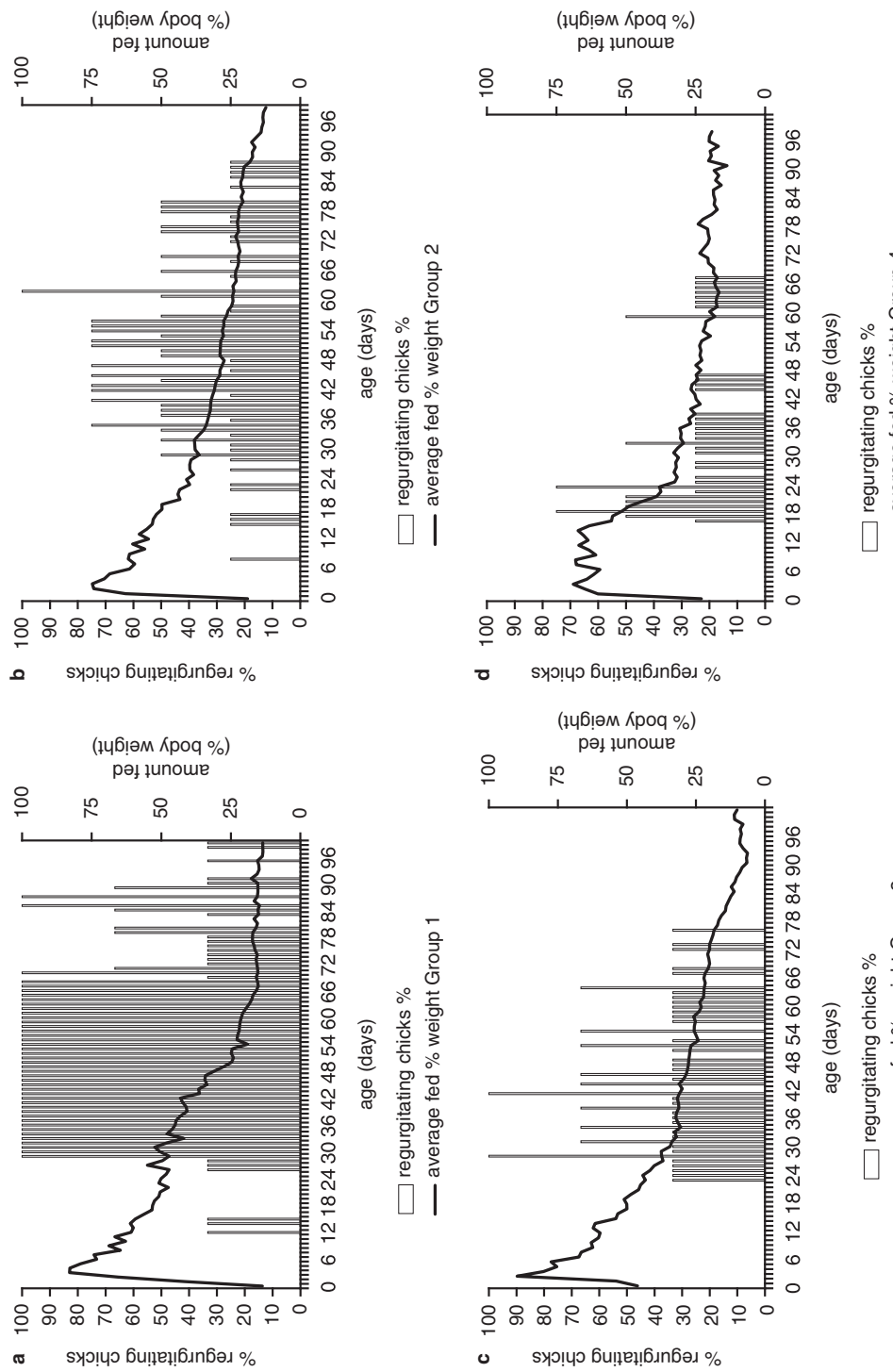

Fig. 3. Association between the average amount fed per day with the percentage of regurgitating chicks for four groups of hand-reared Spix's macaw *Cyanopsitta spixii* **at Al Wabra Wildlife Preservation, 2005–2007: (a) Group 1,** $n = 3$**; (b) Group 2,** $n = 4$**; (c) Group 3,** $n = 3$**; (d) Group 4,** $n = 4$**. Note that regurgitation mostly occurred when higher amounts (in relation to % of body weight) were fed after the initial feeding peak at days 2–5.**

problems with younger chicks as the solid component can often settle in the crop while 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 why the last three feeding protocols are preferred over the first.

CONCLUSIONS

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

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PRODUCTS MENTIONED IN THE TEXT

Enrofloxacin (Baytril 0·5% oral solution®): fluoroquinolone antibiotic, manufactured by Bayer Vital GmbH, 51368 Leverkusen, Germany.

Hero Baby®: baby food (mixed vegetables and apple flavours), manufactured by Hero Espana, E-30820 Alcantarilla (MU), Spain.

Kaytee Macaw Exact Hand-Feeding Formula®: macaw diet, manufactured by Kaytee Products Inc., Chilton, WI, USA.

Kern-440·33N®, Kern-Cm60-2®, Kern-EMB 200®, Kern 440-53®: weighing scales, manufactured by Kern & Sohn GmbH, Balingen, Germany.

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.

Nutribird A19 and A21®: hand-rearing bird diet, manufactured by Versele-Laga, Deinze, Belgium.

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

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

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