



**Facing the Challenge of Spix's Macaw Management  
Optimizing the Husbandry, Veterinary Care and Reproductive Management  
of Spix's Macaw at the Al Wabra Wildlife Preservation.**

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**Abstract**

The Al Wabra Wildlife Preservation (AWWP) is currently home to 51 individuals of one of the world's most threatened parrots, the Spix's Macaw (*Cyanopsitta spixii*). These birds represent 65% of the birds listed in the international studbook for the official captive breeding program, so the AWWP population is very significant and valuable as a conservation resource. Accordingly, AWWP considers many factors in optimizing the management of the birds. Many of the birds initially acquired by AWWP have suffered from veterinary conditions which compromised their health and reproductive status; numerous birds were potential carriers for psittacine diseases. Consequently, it has been essential to implement a strict health-screening, disease management and quarantine regimen, in an attempt to combat the potential risk of disease. In parallel with the veterinary issues, every attempt has been made to encourage the birds to breed successfully, by optimizing housing conditions, husbandry and genetic management. Reproductive potential is also maximized through artificial incubation and hand-rearing techniques, when necessary. Furthermore, attempting to undertake this entire program in a remote desert location, within a small, but rapidly-developing country, presents an additional set of challenges.

**Introduction to Spix's Macaw**

Spix's Macaw was first discovered and collected in 1819 by two European explorers, Dr Johan Baptist Ritter von Spix and Dr Carl Friedrich Philip von Martius; first described six years later by Johan Wagler, who was Spix's assistant and named the bird in his honor. The bird's documented range has been limited to the dry, riverine forest of the Caatinga in northern Bahia, Brazil. Ornithological records suggest that Spix's Macaw was never considered to be abundant in the wild. Avicultural records suggest that the species has always been rare in captivity and highly-prized by collectors.

The demise of the Spix's Macaw has been well documented (Juniper 2002). The primary threat to the species' survival in wild has been poaching of nests for the illegal pet trade. This threat was compounded by a limited species distribution, habitat destruction and the alteration of floral diversity by grazing livestock, as well as invasive bees occupying nesting cavities. These constrictions finally resulted in one lone male surviving in the wild by 1987. A female (probably the original mate of the lone wild male) was released back into the wild in March 1995, but she died approximately two months later after colliding with power lines. The last sighting of the lone male, and consequently the species in the wild, was on 5<sup>th</sup> October 2000; Spix's Macaw is now considered critically endangered and likely to be extinct in the wild (BirdLife International 2007).

In captivity there are currently 79 birds (34.42.3) registered in the official studbook. The official international studbook is overseen by the Brazilian Institute for the Environment and Natural Renewable Resources (IBAMA). 5 institutions are involved in cooperatively managing the registered birds – Lymington Foundation (Brazil), Sao Paulo Zoo (Brazil), Loro Parque Foundation (LPF; Tenerife), Association for the Conservation of Threatened Parrots

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(ACTP; Germany) & AWWP. Although a significant number of undisclosed birds are also thought to exist in private, covert hands throughout the world, the total world population is considered to be less than 130 birds.

**Table 1: Institutions holding Spix's Macaws registered in the official international studbook, July 2007.**

Location	Number of birds held
Al Wabra Wildlife Preservation, Qatar.	21.29.1
Association for the Conservation of Threatened Parrots, Germany.	7.5.2
Loro Parque, Tenerife.	1.5.0
Lymington Foundation, Brazil.	3.2.0
Sao Paulo Zoo, Brazil.	2.1.0
<b>Total</b>	<b>34.42.3</b>

## Historical Perspective of Spix's Macaw at AWWP

The Al Wabra Wildlife Preservation (AWWP) is the private collection of His Excellency Sheikh Saoud Bin Mohammed Bin Ali Al-Thani, located in the state of Qatar. The AWWP collection comprises 52 species of birds, 46 species of mammal and 3 species of herpefauna. There are two main focuses of the bird collection – Birds of Paradise and parrots, with Spix's Macaws being top priority. (See Appendix 1)

The first Spix's Macaws arrived at AWWP in February 2000, when 2 pairs arrived from Birds International Incorporated (BII; Antonio de Dios), Philippines. Subsequent shipments arrived from Roland Messer's Swiss collection and a further 25 birds from BII. Since these Philippine birds represented a significant proportion of the world's population, it was necessary to transfer them to Qatar in four shipments, to ameliorate the potential impact of logistical difficulties, or even a plane crash.

In January 2004, AWWP took over the management of Roland Messer's collection of 13 birds. In March that year AWWP took ownership of 11 of these birds; the ownership of one pair from these birds, with the only significant breeding potential, was retained by Messer. This pair produced 2 offspring in June 2004 – the first Spix's Macaws bred under AWWP management. Subsequently in August 2005, this pair plus one of their male offspring was transferred to the ACTP's collection in Germany. In September 2005, an attempt was made to break into the Swiss Spix's Macaw facility. Under the pressure of inadequate security, AWWP explored options for these 12 birds. In the absence of suitable alternatives, these birds were finally transferred to the AWWP's main facilities in Qatar in October 2005.

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**Table 2: Historical overview of AWWP Spix's Macaw population.**

Year	AWWP Recruitment	AWWP Immigration	AWWP Mortality	AWWP Emigration	Comments	AWWP End-of-year Total	Registered World Total
2000	0.0	2.2	0.0	0.0	Feb 2000: 2.2 arrive from BII, Philippines.	2.2	53
2001	0.0	0.0	0.0	0.0		2.2	57
2002	0.0	1.3	0.0	0.0	Nov 2002: 1.3 arrive from Roland Messer, Switzerland.	3.5	55
2003	0.0	3.3	2.0	0.0	Aug 2003: Permits issued for BII's 25 remaining birds to be legally transferred from Philippines to Qatar. Nov 2003: First shipment of 3.3 birds arrives from BII, Philippines.	4.8	53
2004	2.0	18.14	2.1	0.0	Jan 2004: Second shipment of 4.3 birds arrives from BII, Philippines. Jan 2004: AWWP takes over the management of Roland Messer's remaining 6.7 birds, still in Switzerland. March 2004: Third shipment of 4.5 birds and fourth shipment of 3.0 birds arrive from BII, Philippines. March 2004: AWWP takes ownership of 11 of the 13 Swiss-based birds.	22.21	54
2005	0.3	0.0	2.1	2.1 (managed only by AWWP)	Aug 2005: 2.1 birds (breeding pair & 1 offspring still owned by Messer) sent to Martin Guth (ACTP) in Germany. Sept 2005: Serious attempt to break into Swiss breeding facility. Oct 2005: 6.6 birds transferred from AWWP Swiss facility to Qatar.	18.22	54
2006	2.5	0.0	0.0	0.0		20.27	74
2007	1.2.1	0.0	0.0	0.0		21.29.1	79
<b>Total</b>	<b>5.10.1</b>	<b>24.22</b>	<b>6.2</b>	<b>2.1</b>			

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## Veterinary Management: Disease Monitoring & Quarantine

When AWWP received its Philippine consignment of 25 Spix's Macaws in late-2003 / early-2004, it was fully recognized that these birds could be potential carriers of disease. At BII the Spix's Macaw flock had suffered from diseases, which had also caused an impact on the breeding success of their birds. Similarly, soon after AWWP acquired its Swiss birds, it became apparent that all 11 of the birds acquired by AWWP suffered from some kind of behavioral problem or physiological ailment (including Proventricular Dilatation Disease in one bird).

In the interest of bio-security and population management, AWWP continued to manage the Swiss population separately from the Qatar population. However, following the attempted theft of the birds in Sept 2005, and a failure to find suitable arrangements elsewhere, the only viable option was to bring the birds to Qatar. Upon their arrival in Qatar, all 12 of the Swiss birds were installed directly into a temporary quarantine facility for between 6 to 12 months.

When AWWP took over the management of the Philippine and Swiss birds, it was already acknowledged that disease control and treatment were going to be present immense challenges.

Upon arrival at AWWP, each bird was initiated on a rigorous program of health screening. Proventricular Dilatation Disease (PDD) had already been identified as a problem in the newly-acquired population, and crop biopsies were essential for more thorough diagnosis. Other diseases of particular concern included Avian Herpes Virus (AHV), Avian Paramyxovirus (APMV), Avian Polyoma Virus (APV), Avian Chlamydia / Psittacosis, Psittacine Beak and Feather Disease and Avian Tuberculosis. Additionally, all birds were endoscoped to assess breeding condition / gonad maturation and abnormalities in internal organs. The health checks revealed that birds from both the Swiss and Philippine populations had been exposed to PDD, APV, APMV, AHV and Avian Chlamydia; there also appeared to be a high incidence of *Pseudomonas aeruginosa* in choanal or cloacal swabs, even in birds displaying no clinical symptoms.

On the basis of an assessment of the risk of virus transmission that each bird presented for others in the captive population, each individual was assigned the status of one of three colors – green, yellow or red (see Tables 3a & 3b.). Since the purpose of AWWP's Spix's Macaw program is captive propagation as a conservation tool, it was inherently necessary to start establishing birds as breeding pairs, with major consideration given to their risk of virus transmission. As a general rule, 'green' birds should be paired with other 'green' birds, and never 'red' birds; 'red' birds should be paired with other 'red' birds; 'yellow' birds should be paired with other 'yellow' birds but for the sake of maximizing reproduction within the flock, could potentially be paired with either 'green' or 'red' birds.

Whilst the newly acquired birds were being kept in the quarantine facility and health checks undertaken, two purpose-built, 10-aviary breeding complexes were being constructed at AWWP to house the birds, whose population now numbered more than 40. One of the primary considerations in the design of these complexes was the strategy to maintain each individual aviary as a form of quarantine unit. (See 'Housing and husbandry' below.) Even when set up as breeding pairs, each pair can be kept in isolation from other birds. This even allows for 'red' birds to be kept in the same complex as 'green' ones, although naturally in separate aviaries and pairs.

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The health-screening program has continued, with all birds receiving an examination every 12 months – diagnostic analysis of blood (including serum chemistry, Complete Blood Counts, serology and PCR for detection of viruses), cloacal and choanal swabs for bacteriology and x-ray examination being the minimum. Notably, it is possible for a bird's disease transmission risk assessment to change from year to year, with subsequent checks revealing or eliminating symptoms that were not recorded or suspected in previous examinations.

The health-screening program has also enabled us to assess the overall condition of an individual bird's health, with a particular focus on the health of its reproductive system. Each bird is assigned a score which reflects the bird's clinical or apparent health condition and its viability to be reproductively successful – score 1 for very good, score 5 for poor. (Again, see Tables 3a & 3b.) This individual score provides another guide for the selection of pairs, enabling us to select pairs with the greatest breeding potential.

The health-screening and physical examinations have also provided some interesting discoveries. Endoscopy revealed that the AWWP Spix's Macaws appear to have unusual air-sac physiology, with certain air-sac walls appearing in random locations and occasionally missing all together in some individuals. This may be a natural phenomenon, or may even be the result of frequent endoscopies or previous infections. The air-sacs of the Philippine birds were very cloudy and many of them exhibited an anthracosis of the lungs, the incidence of which was higher in older birds – a possible consequence of the heavy air pollution around Manila. Anthracosis was also found in several organs and skeletal tissue of ribs and skull on post mortem examination. The Philippine population all had extremely dark irises, whilst all the Swiss birds have white irises. One can speculate that the dark iris represents a heavy metal accumulation, as certain heavy metals are known to deposit in the eyes; these heavy metals may also be found in high concentrations in the polluted air around Manila. There is now evidence that suggests that the degree of anthracosis in the birds' lungs may reduce with time as pollutants are purged from the bird's body in cleaner air; it is also a possibility that the color of the iris may do the same.

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**Table 3a: AWWP-health status scoring system**

<b>Virus transmission risk assessment:</b> based on the results of viral tests and biopsies.		<b>Individual health assessment:</b> based on health check (x-ray, blood screens, clinical signs etc...)	
<b>Green</b>	<b>No risk;</b> all pairing possible	<b>score 1</b>	<b>Very good:</b> If no abnormalities are detected in all tests & examinations.
<b>Yellow</b>	<b>Less risk;</b> virus transmission not ruled out; restricted pairing	<b>score 2</b>	<b>Good:</b> If it is positive for one test but no clinical signs.
<b>Red</b>	<b>High risk;</b> virus carrier; restricted pairing, never with green color.	<b>score 3</b>	<b>Fair/average:</b> If it is positive for two tests but no clinical signs.
		<b>score 4</b>	<b>Below average:</b> If it is positive for two tests and clinical signs.
		<b>score 5</b>	<b>Poor/bad:</b> Most of the tests positive and clinical signs.

**Table 3b: Overview of the health status of AWWP Spix's Macaw flock, July 2007.**

Number of birds in each category. N = 36 adult breeding. N = 5 adult non-breeding. N = 10 juveniles		Virus transmission risk assessment								
		Green			Yellow			Red		
		Adult breeding	Adult non-breeding	Juvenile	Adult breeding	Adult non-breeding	Juvenile	Adult breeding	Adult non-breeding	Juvenile
<b>Individual health assessment</b>	<b>(score 1)</b> Very good	1	-	7	3	-	1	-	-	-
	<b>(score 2)</b> Good	5	1	2	13	-	-	2	-	-
	<b>(score 3)</b> Fair	2	-	-	6	1	-	2	-	-
	<b>(score 4)</b> Below average	1	-	-	1	-	-	-	1	-
	<b>(score 5)</b> Poor	-	-	-	-	-	-	-	2	-

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## Veterinary Management: The impact of Proventricular Dilatation Disease.

Proventricular Dilatation Disease (PDD) has been implicated in five of the eight deaths of Spix's Macaws at AWWP. Three of these PDD-related deaths occurred in 2004, in birds we had accepted knowing that they were not healthy, and possibly suffering from PDD.

It has been noted at AWWP that Spix's Macaws affected with PDD do not develop the typical massively dilated proventriculus or pass undigested seeds in the droppings, as is typical for the disease (Hammer 2005). Instead, they suffer progressive damage to the Central Nervous System (CNS) and, despite the presumptive diagnosis from the results of the crop biopsy, PDD may often only be confirmed when necropsy samples from the CNS, adrenals, heart and digestive organs are sent for histopathological examination.

Clearly the diagnosis of PDD is a key consideration in the monitoring of the Spix's Macaw population. A crop biopsy is considered to have a sensitivity of between 60-70% for detecting the changes in nerve cells caused by PDD. A positive test for PDD is said to be definitive, but a negative (no obvious lesions) test is no guarantee that a bird is free of the disease even if they present otherwise healthy indications. Since 2004, 73 crop biopsies have been taken from 46 individual Spix's Macaws at AWWP, with several individuals having had as many as three biopsies during this period.

Sometimes a bird may present suspicious crop biopsy result for PDD, indicated by signs of lymphoplasmacytic inflammation surrounding the ganglia, but not within the ganglia. This bird is managed as though it is PDD positive in order to mitigate the risk to the rest of the breeding population, and is initially assigned the risk assessment color red. Notably, seven of the nine living birds to test suspicious for PDD, have done so in a single crop biopsy and have not exhibited obvious lesions in subsequent crop biopsies, thereby raising their status to the colour yellow.

One bird (marked with \* in Table 4) tested positive for PDD by crop biopsy in 2004, but subsequently has had no obvious lesions (indicating a negative result) from biopsies in 2006 and 2007. Radiographs show that although the bird does have an enlarged proventriculus in comparison to other Spix's Macaws the size does not appear to have changed over the subsequent 3 years. This bird has never shown any of the classical signs of the disease, nor any of the CNS symptoms now associated with the disease in the Spix's Macaw. This may suggest that this bird has overcome a PDD infection.

**Table 4: Survivability of Spix's Macaws following the results of PDD crop biopsies, July 2007.**

Crop biopsy results for PDD N = 46 birds	Number of birds		
	Total tested	Dead	Alive
<b>Positive</b> at least once.	3	2	1*
<b>Suspicious</b> at least once, but never positive.	12	3	9
<b>Negative</b> always.	31	0	31

## Veterinary Management: Disease Treatment & Disease Prevention.

Avian Polyoma Virus (APV) does not appear to be a significant cause of mortality in the Spix's Macaw population at AWWP. We have detected APV anti-bodies in 26 out of 50 Spix's Macaws tested, but no mortalities have been directly attributed to the disease (Deb 2007). However, it is known from other species that adult parrots with sub-clinical infections may transmit the virus to chicks and fledglings, especially hand-reared ones which are

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immunologically naïve when introduced to the breeding population, and therefore much more susceptible to acute disease and mortality as a result. Consequently, all hand-reared psittacines at AWWP are vaccinated against APV at 5 weeks of age followed by a booster 3 weeks later using a commercially available killed APV vaccine (PSITTIMUNE® APV, www.baymunecompany.com, USA). Parent-reared psittacine chicks are not vaccinated, since it is assumed that they would have already had sufficient exposure to the virus in small quantities, if carried by their parents. In this way parent-reared chicks will receive a natural immunization against APV. To date, however, no Spix's Macaw chicks have been parent-reared.

None of AWWP's psittacines, including the Spix's Macaws, are vaccinated against any Avian Paramyxovirus (APMV), since it has been suggested that there is a link between the APMV vaccine and the onset of PDD. It has even been suggested that APMV strain 1 can be used as a preliminary indicator for the presence of PDD in a psittacine collection (Grund 1999). Until the link between the APMV-1 virus, the vaccine, and PDD are fully explored, we will not vaccinate against APMV. This is supported by the evidence that AWWP has experienced no mortality attributable to APMV, while PDD is a major threat. (Table 5)

Additionally, Qatar has so far not experienced any incidents of Highly Pathogenic Avian Influenza H5N1. Although Avian Influenza remains a serious threat to our birds, it is currently illegal to vaccinate birds against the disease in Qatar. Fortunately, we have the capability to permanently shut a large proportion of our bird collection, including all the Spix Macaws, into indoor aviaries (see 'Housing'). This allows us to isolate each of the bird buildings from the outside world, by the use of quarantine measures, such as footbaths, clothing changes, special trained staff and other sanitary measures, allowing sufficient protection from any external Avian Influenza threat.

Whilst we continue to take every measure to limit transmission of disease to and through our Spix's Macaw population, we still have to manage a flock of birds which contains many compromised birds. With the goal of improving the health of these birds, as well as ensuring the healthy birds remain in good condition, we undertake routine monthly fecal checks to evaluate any parasite infestation and to monitor the balance of bacteria in the gut. Weekly weighing allows us to monitor the weight of each bird. (Each Spix's Macaw is conditioned to perch on an electronic weighing scale.) The annual health checks enable us to diagnose and monitor any chronic conditions. Lastly, AWWP maintains a staff of four permanent veterinarians and one laboratory staff to manage ongoing veterinary cases and provide immediate treatment, if necessary.

**Table 5: Summary of disease exposure and mortality in the AWWP Spix Macaw population**

Disease	Number of birds		
	Total tested	positive result for antibodies	mortality due to disease
Avian Polyoma Virus	50	26	0
Avian Herpes Virus	57	10	0
Avian Paramyxovirus Type 1	57	17	0
Psittacosis / Avian Chlamydia	48	20	0
Avian Tuberculosis	45	0	0



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**Table 6: Annual mortality according to age class, since 2002.**

Year	Annual mortality			Comments / causes of death
	Nestlings & fledglings	Juveniles & Adults	Total*	
2000	- (n = 0 from 0)	0% (n = 0 from 4)	0% (n = 0 from 4)	
2001	- (n = 0 from 0)	0% (n = 0 from 4)	0% (n = 0 from 4)	
2002	- (n = 0 from 0)	0% (n = 0 from 8)	0% (n = 0 from 8)	
2003	- (n = 0 from 0)	<b>14.3%</b> (n = 2 from 14)	<b>14.3%</b> (n = 2 from 14)	1.0 – Kidney failure. 1.0 – Stroke, kidney failure.
2004	0% (n = 0 from 2)	<b>6.8%</b> (n = 3 from 44)	<b>6.5%</b> (n = 3 from 46)	0.1 – PDD confirmed. 1.0 – Lung bleeding, kidney failure. 1.0 – Euthanized; (PDD confirmed after death)
2005	0% (n = 0 from 3)	<b>6.9%</b> (n = 3 from 43)	<b>6.5%</b> (n = 3 from 46)	1.0 – PDD confirmed. 0.1 – PDD confirmed. 1.0 – Auto-mutilation, lesions of peripheral nerves, kidney failure.
2006	0% (n = 0 from 7)	0% (n = 0 from 40)	0% (n = 0 from 47)	
2007	0% (n = 0 from 4)	0% (n = 0 from 47)	0% (n = 0 from 51)	

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\* Sample size includes all birds maintained at AWWP throughout the year, including hatches and mortality, immigration and emigration. Consequently, the total may be larger than the actual total on any particular moment of the year.

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## Housing

AWWP's two primary Spix's Macaw breeding facilities have been constructed, combining strategies that attempt to:

1. Optimize husbandry & well-being.
2. Optimize breeding success.
3. Minimize disease transmission between different pairs.
4. Optimize aviary maintenance and civil engineering services.

Each of the 20 uniform aviaries is intended for keeping no more than 1 pair. Due to the brutal heat and sunshine of the Qatari summer, each aviary has both an indoor and outdoor compartment – the indoor compartment is air-conditioned, and the roof of the outdoor compartment is covered in shade netting. The birds have free access between the indoor and outdoor compartments (except when bird management prohibits it) through two windows big enough for the birds to fly directly.

The indoor compartment of each aviary measures 4m x 4m x 2.8m, and is surrounded on two sides by an L-shaped service corridor. The indoor aviary is serviced through the wire front, where two externally-mounted feeding stations facilitate food and water provision, whilst minimizing the time spent inside the aviary itself for cleaning. Along the side of the aviary, a brick wall limits visual disturbance to the birds, whilst the service corridor accesses the outdoor section and nest boxes.

The nest boxes are all located within the indoor compartment, with external hatches enabling access for nest inspections without the need to enter the aviary itself. A transparent plastic box is designed to house surveillance cameras. The air-conditioning unit is strategically placed to avoid draughts blowing directly onto the birds. Lighting is controlled by automatic timers and adjusted according to the length of the day. Glass windows are also installed above mesh roof level of the indoor compartment so as to allow more daylight. The substrate inside the indoor compartment is a 5cm layer of fine dune sand, with solid concrete floor beneath.

The outdoor compartment measures 5.6m x 5.6m x 2.8m, and is surrounded on 3 sides by solid walls, with a wire mesh front. A 25cm distance separates two layers of mesh roofing, in between which lies an artificial rain sprinkler system. As well as sun-protection, the shade-netting also doubles as considerable protection against droppings from wild birds. The substrate of the outdoor aviaries is either solid concrete or 15-20cm of washed sand – both provide a clean, well-drained surface. The aviaries are furnished with a variety of perches, ropes and living plants, such as grasses, shrubs and small trees. An outdoor service corridor allows for observation of the birds, as well as occasional access to the outdoor aviary.

Not only do the solid concrete walls provide visual barriers between pairs, but crucially they also act as a physical barrier to the transmission of pathogens between adjacent aviaries. This enables each aviary to be considered an individual unit, in isolation from all others. Equally important, each aviary unit has its own individual access door, with no connecting access to neighbouring aviaries. Similarly, each aviary is equipped with its own footwear and tools for cleaning, to avoid the spread of pathogens between aviaries.

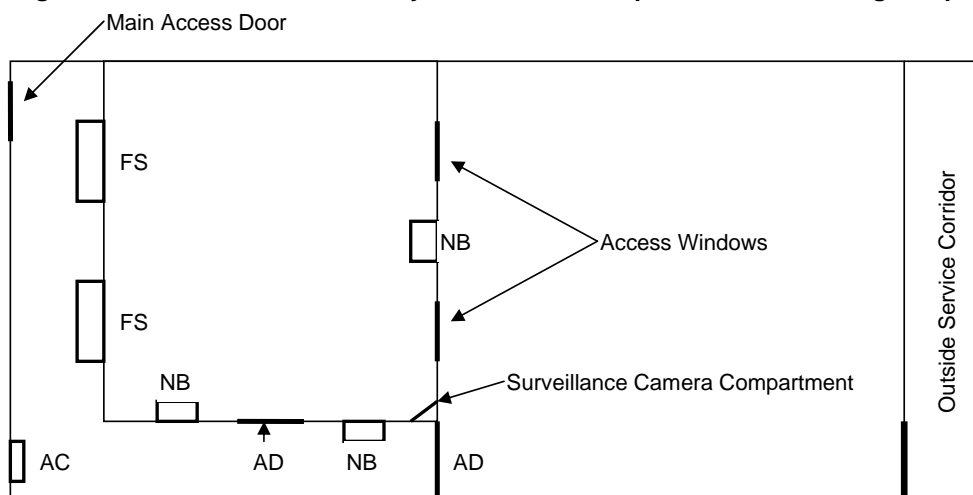
Pest control considerations include the use of 2inch x ½inch mesh which should prevent the passage of rats and adult mice. Similarly the use of solid concrete throughout the construction should eliminate cavities which might harbor mice. Finally, a narrow moat around the entire complex helps to prevent the passage of ants into the feeding stations.

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**Diagram 1: Plan of an isolated aviary unit in AWWP's Spix's Macaw breeding complex.**



FS – Feeding Station, NB – Nest Box, AD – Access Door, AC – Air Conditioning

## Husbandry & Diet

Strict dietary provisioning is a very important consideration in maintaining healthy Spix's Macaws (Watson 2006). A high fat content in their diet, due to nuts and sunflower seeds, can easily lead to obesity. One bird arrived in Qatar from Switzerland, weighing 546g and was so obese he could not fly. In comparison, the average weights for healthy Spix's Macaws are 318g for males and 288g for females (AWWP, unpublished data). This male has now decreased in weight to 346g, thanks to a strict maintenance diet, is now healthy and can fly perfectly.

Similarly, like many species, it appears that Spix's Macaws are not capable of nutritional wisdom. Consequently they are provided with a varied and balanced diet, but in a very limited quantity. This ensures that each bird consumes the majority of the contents of its food dish, ensuring a nutritionally balanced food intake.

All the birds (in the entire AWWP bird collection) are fed twice per day. Every day the Spix's Macaws receive a morning food dish at 6a.m., containing mostly fruit salad, vegetables, pulses and sprouted seeds. Between 3-4p.m., the birds receive an afternoon food dish, which contains a mixture of pellets, seeds and nuts. This food dish is left in the feeding station overnight, and is often presented in ways which encourage more active foraging behaviours and prolong the time spent feeding (such as hidden amongst wood shavings). Tables 7a & 7b present details of the current Spix's Macaw diet at AWWP.

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**Table 7a: Spix's Macaw diet at AWWP**

Food Items	Spix's Macaw Maintenance Diet		Spix's Macaw Breeding Diet	
	Morning: per pair	Afternoon: per pair	Morning: per pair	Afternoon: per pair
Parrot soft food mix	2 table spoon (30g).	-	3 table spoon (45g).	-
Fruit salad	2 table spoon (30g).	-	2 table spoon (30g).	-
Zeigler pellets maintenance®:	4 pieces (5g).	8 pieces (10g)	-	-
Zeigler pellets breeder®:	-	-	4 pieces (5g).	12 pieces (10g).
Milk thistle seed	8 seeds (1g).	8 seeds (1g).	8 seeds (1g).	8 seeds (1g).
Spix's Macaw dry food mix	-	1 table spoon (15g).	-	1 table spoon (15g).
Almonds: Mon/Wed/Fri/Sun	-	2-pieces.	2-pieces.	2 pieces.
Walnuts: Tues/Thur/Sat	-	2-halves.	-	2 halves.
Hard boiled egg	-	-	1 table spoon (10g).	-
Crushed mineral block	-	(1g).	-	(1g).

**Table 7b: Composition of Spix's Macaw diet mixes**

Parrot soft food mix		Spix's Macaw dry food mix		Fruit salad	
Mixed frozen veg	5 parts.	Harrison maintenance pellets (fine)®	5 parts.	Apple	Papaya
Boiled seed	3 parts.	NutriBird - P15 pellets: 50:50 original/tropical®	2 parts.	Banana	Red Chili
				Broccoli	Pear
Sprouted seed	2 parts.	Prestige - Parrot premium mix®:	2 parts.	Endives	Carrot
				Mango	Orange
100% cranberry concentrate:	2ml per cup (250ml) of mix	Prestige - Tropical finch mix®:	1 part.	Celery Heads	
					Red Bell-peppers
				<i>Mixture varies on a weekly cycle.</i>	

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The process of providing adequate supplies of fresh, clean water in the middle of the desert is not without its challenges. At AWWP, drinking water is brought in from a local town by tanker-truck; before being given as drinking water to the birds, the water is triple-filtered to eliminate bacterial contamination.

The desert heat can lead to rapid decomposition and bacterial contamination of fresh diet items, so specific precautions are taken to limit this threat. During the summer months, the morning food dish containing fruit and vegetables is removed between 8.30-9a.m.; during the winter the food is removed in early afternoon. At this time, the spilled food is also picked up off the aviary floor, as necessary. Similarly, the process of sprouting seeds involves soaking them in a dilute (1:500) concentration of F10<sup>®</sup> ([www.healthandhygiene.net](http://www.healthandhygiene.net), South Africa) disinfectant and triple filtered water, and leaving them in cool room at 16°C for 36 hours whilst they germinate. Followed by repeated washing before it is offered to the birds.

The sandy substrate of indoor aviaries is sieved clean every other day. Minimal food remains are discarded in the outdoor aviary, but these are also removed when necessary. The use of the feeding stations ensures that approximately 90% of the food discarded by the Spix's Macaws falls on the base of the feeding station or the floor of the service corridor beneath it. This greatly reduces the amount of time that birds are disturbed inside their aviaries by the cleaning process. In order to ensure high levels of food hygiene, the feeding station itself is scrubbed every other day

Since the majority of the Spix's Macaws arrived in Qatar in 2004, there have been significant improvements in the general health of the flock. Anecdotally, we can state that the feather condition of the birds has improved and there has been a significant increase in their activity level. At the time of writing we had suffered no Spix's Macaw mortality since 2005 and the incidence of illness has been negligible during this time. We attribute the improved health of the flock to both the rigorous program of veterinary monitoring and management, as well as high standards of housing and diet.

However, it is acknowledged that since the Spix Macaws started breeding in earnest in 2004, we have not experienced a significant improvement in either fertility or hatchability, nor in the fecundity or productivity of the flock. Although the reproductive potential of the flock is undoubtedly better than it was prior to their assemblage at AWWP, we are still presented with some huge challenges to maximize productivity.

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**Table 8: Reproductive statistics of AWWP flock 2003 – 2007.**

	<b>2003</b>	<b>2004 Qatar</b>	<b>2004 Swiss</b>	<b>2005 Qatar</b>	<b>2005 Swiss</b>
Number of egg-laying females	1	2	3	3	2
Number of eggs laid	6	12	28	15	19
Number off eggs broken pre-fertility	0	1	2	0	1
Percentage confirmed fertility	0% (n = 0 from 6)	25% (n = 3 from 12)	46% (n = 13 from 28)	20% (n = 3 from 15)	5% (n = 1 from 19)
Fertile, but no development	-	0% (n = 0 from 3)	8% (n = 1 from 13)	0% (n = 0 from 3)	0% (n = 0 from 1)
Percentage early embryo deaths	-	0% (n = 0 from 3)	23% (n = 3 from 13)	0% (n = 0 from 3)	0% (n = 0 from 1)
Percentage mid embryo deaths	-	67% (n = 2 from 3)	31% (n = 4 from 13)	0% (n = 0 from 3)	0% (n = 0 from 1)
Percentage late embryo deaths	-	33% (n = 1 from 3)	23% (n = 3 from 13)	0% (n = 0 from 3)	100% (n = 1 from 1)
% Fertile egg broken	-	0% (n = 0 from 3)	0% (n = 0 from 13)	0% (n = 0 from 3)	0% (n = 0 from 1)
Percentage hatchability	-	0% (n = 0 from 3)	15% (n = 2 from 13)	100% (n = 3 from 3)	0% (n = 0 from 1)
Number of chicks surviving	-	-	<b>2</b>	<b>3</b>	-
Percentage chick survivability	-	-	100% (n = from 2)	100% (n = 3 from 3)	-

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**Table 8 (cont): Reproductive statistics of AWWP flock 2003 – 2007.**

	<b>2006</b>	<b>2007</b>	<b>Total</b>
Number of egg-laying females	2	5	<b>10</b>
Number of eggs laid	12	32	<b>124</b>
Number of eggs broken pre-fertility	0	0	<b>4</b>
Percentage confirmed fertility	86% (n = 10 from 12)	22% (n = 7 from 32)	<b>30%</b> <b>(n = 37 from 124)</b>
Fertile, but no development	0% (n = 0 from 10)	0% (n = 0 from 7)	<b>3%</b> <b>(n = 1 from 37)</b>
Percentage early embryo deaths	0% (n = 0 from 10)	14% (n = 1 from 7)	<b>11%</b> <b>(n = 4 from 37)</b>
Percentage mid embryo deaths	0% (n = 0 from 10)	0% (n = 0 from 7)	<b>16%</b> <b>(n = 6 from 37)</b>
Percentage late embryo deaths	20% (n = 2 from 10)	29% (n = 2 from 7)	<b>24%</b> <b>(n = 9 from 37)</b>
% Fertile egg broken	10% (n = 1 from 10)	0% (n = 0 from 7)	<b>3%</b> <b>(n = 1 from 37)</b>
Percentage hatchability	70% (n = 7 from 10)	57% (n = 4 from 7)	<b>43%</b> <b>(n = 16 from 37)</b>
<b>Number of chicks surviving</b>	<b>7</b>	<b>4</b>	<b>16</b>
Percentage chick survivability	100% (n = 7 from 7)	100% (n = 4 from 4)	<b>100%</b> <b>(n = 16 from 16)</b>

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**Table 9a: Contribution by females to reproductive effort 2003-2007**

	Breeding season					Total 2003-2007
	2003	2004	2005	2006	2007	
Number of females in AWWP flock	5	21	20	22	27	30
Number of females set up in a breeding pair	2	8	15	14	18	22
Number of females laying eggs	1	5	5	2	5	10
Number of females laying fertile eggs	0	3	3	2	2	6
Number of females successfully producing offspring	0	1	2	2	1	4

**Table 9b: Contribution by males to reproductive effort 2003-2007**

	Breeding season					Total 2003-2007
	2003	2004	2005	2006	2007	
Number of males in AWWP flock	3	20	18	18	20	28
Number of males set up in a breeding pair	2	8	15	14	18	22
Number of males fertilizing eggs	1	5	5	2	5	6
Number of males successfully producing offspring	0	1	2	2	1	4



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## Optimizing Breeding Success.

When the majority of the birds were acquired into the AWWP flock in 2004, it was already recognized that the physical, behavioral or reproductive condition of many of the birds was so poor that the potential for reproduction was going to be limited. It was even anticipated that a significant number of birds might never breed.

Table 8 displays the summary of the reproductive output of the flock since the AWWP program began in 2003. Of the 124 eggs laid, only 37 have had confirmed fertility – 30% fertility. Of these fertile eggs, only 16 eggs have hatched – 43% hatchability. The one piece of good news is that all 16 chicks that hatched have been raised successfully.

The problems of fertility and hatchability are further compounded by a lack of egg-laying potential of the flock. Of the 30 females that have been kept at Al Wabra, only 10 females have ever laid eggs. Of these 10 females who have laid eggs, only 6 have produced fertile eggs, and only 4 females have produced offspring. Similarly, of the 28 males that have been kept at Al Wabra, only 6 males have fertilized eggs, and only 4 males have produced offspring. (See Tables 9a & 9b)

The current situation is still rather frustrating. During the 2007 breeding season, whilst there were a total of 27 females in the flock, only 5 females laid eggs and only 2 females produced fertile eggs. Similarly, during the 2007 breeding season, whilst there were a total of 20 males in the flock, only 2 males fertilized eggs. At this time, there were 8 females and 3 males who were too young to breed, but there were a total of 14 other females and 10 males of breeding age, who made no contribution to the reproductive effort. (See Table 9a & 9b)

Appendix Table A1 shows the egg production and fertility of the individual females; Appendix Table A2 shows the hatchability of eggs from the individual females. Clearly there are some major challenges faced in increasing the reproductive effort of the flock. Listed below are some explanations for the problems so far encountered.

- The potential fecundity, fertility and productivity of the AWWP flock were reduced by the 2005 transfer of the Swiss female #4329 to ACTP in Germany. Unfortunately, she has not yet produced offspring in Germany, but she has recently been paired with a male transferred from Loro Parque Foundation and there are optimistic signs that she will breed again in the future.
- Female #3254 who was an egg-laying female in 2003, was later diagnosed as being suspicious for PDD, and has consequently been kept in isolation. Two subsequent crop biopsies in 2006 and 2007 revealed no obvious lesions. Other health parameters indicate that she is in very good health, so in March 2007 she was cleared to return to breeding status and moved to the breeding center to be paired with a new mate.
- Female #4332 laid 18 eggs in 2004 & 2005, all of which were infertile. Although this was a behaviorally compatible pairing, the male has since been evaluated by endoscopy and testis biopsy as having very low chances of fertility. The female has since been re-paired with another male, but is yet to produce eggs.
- Female #4365 and #4366 both laid their first eggs in 2007, but neither female produced fertile eggs. #4365 was endoscoped prior to the 2007 breeding season, and she was assessed as having poor reproductive potential – the outcome of eggs being laid is progress in itself.
- Female #4369 produced 7 fertile eggs and 5 offspring in 2006. However, in 2007 all 7 of her eggs were infertile, despite being observed mating frequently and over prolonged copulations. The reasons for the lack of fertility in 2007 are currently unknown.
- Female #3253 has produced 10 eggs, of which 6 were fertile. However, the hatchability of these eggs has sadly been 0%. In 2004, her 3 fertile eggs died as embryos; similarly

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her 3 fertile eggs died as embryos in 2007, and 2 of these were found to be deformed. Recent micro-satellite DNA analysis to evaluate the gene pool of the IBAMA-managed breeding program has now shown that she shares a very high mean kinship with her mate (Presti et al, in prep.) This exemplifies the difficulty in managing a population with undocumented sources for founders. However, this result is no great surprise, since it is known that the final remnant population of Spix's Macaws in the wild was very small, and it is probable that many of the founders of the breeding program were originally poached as chicks from the very last wild nest cavity along the Melancia Creek. This bird and her former mate have been re-paired in time for the 2008 season.

- Furthermore, we are discovering a trend of high incidences of immature gonads in both males and female at ages when they should be considered sexually mature – older than 6 years. For example #3252 was 9 years-old during the 2006 season, and this was her third season as a breeding arrangement. In this time she failed to lay any eggs, despite showing all other typical breeding behaviors such as allo-feeding, allo-preening, frequent copulation and regular activity in the nest cavity. When she was endoscoped in January 2007 her primary ovary was still found to be in a stage of early maturation. Conversely, a Qatar-bred female #5158 was found to have an ovary at an advanced stage of maturation despite being only 20-months old. We hypothesize that birds in large communal aviaries as youngsters rapidly reach a level of maturity, due to increased stimulation of the pituitary gland. Meanwhile, those youngsters maintained in small aviaries for long periods with insufficient exercise and mental stimulation, lack physical fitness, have reduced endocrine function and are slow in sexual maturation. Alternatively, the late maturation might be attributable to an inbred population, a limited gene pool or prior health issues.

Naturally every attempt is being made to increase the reproductive potential of the AWWP flock. Four criteria are taken into account when selecting potentially compatible new pairs:

- 1) Reproductive ranking, based on a scoring system for gonads when viewed via endoscopy during a health check, combined with the individual's breeding history, if it has one.
- 2) Genetic compatibility – the new study of micro-satellite analysis will provide a valuable, accurate perspective on genetically-compatible pairings. Previously, genetic compatibility had been based on historical evidence and assumptions.
- 3) Health status, according to the red-yellow-green system, to avoid combinations that present a high risk of disease transfer.
- 4) Age of birds - pairing birds of a similar age can maximize the breeding life span of the pair.

During the selection process, females are graded according to their reproductive ranking, and then mates are selected according to criteria 2-4.

Of course, the final evaluation of a pair's compatibility is based upon the temperament and behavior of the pair – this decision is obviously made by the birds, but we must be flexible to re-evaluate behaviorally-incompatible pairs. Conversely, disease management can impede pair selection on the basis of all the other criteria, particularly behavioral. Consequently, many of the current pairings are forced pairings because we have not been able to flock birds for self selection due to our strategy to control PDD. Unfortunately, Spix's Macaws also appear to be very amenable to their cage-mate, whether they are a bonded pair or not. This makes the assessment of breeding compatibility more difficult. With young, presumably PDD-negative birds soon to be recruited into the breeding population, it is hoped that in the near-future we can use the strategy of off-season flocking of small groups, to enable the pairs to self-select. We have already been keeping juvenile Spix's Macaws in large flocking aviaries (15-20m long) with natural substrates, perching and vegetation, with an artificial rain

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system. We hope that these conditions will also provide sufficient stimuli to encourage maturation of the gonads, and will ensure that birds will be recruited into the breeding population at a younger age in the near future.

Optimizing reproductive output is a balance between short-term breeding success and long-term fecundity. We encourage females to lay a maximum of two clutches of eggs during the spring breeding season; the typical clutch size is four eggs. At AWWP we often experience a secondary breeding season in the autumn – if pairs choose to lay another clutch again then we do not prevent them.

Whenever possible, if the pair have proven themselves as reliable parental incubators, we leave the eggs under the pair until 1-2 days before each is due to externally pip. This ensures that the incubation process is as natural as possible, and hopefully maximizes hatchability. At this point the eggs are placed in an incubator / hatcher for the hatching process. After hatching, the chicks are hand-reared. Crucially, hand-rearing significantly helps to minimize the risks of disease transmission from parent to offspring, thereby increasing the chances of PDD-negative youngsters into the captive flock, and thereby providing more options for mate-selection in the future.

In order to monitor incubation and other breeding behaviors, all 20 of the indoor aviaries in the Spix's Macaw breeding complex are designed with the option of installing surveillance cameras. Similarly, in the future we aim to install nest box cameras which will provide a more detailed insight into the parents' behavior at the nest, and hopefully enable us to respond even more rapidly in emergency interventions.

To date, the hand-rearing effort has been completely successful, with all 16 chicks hatched being raised to independence. Although the principles and process of hand-rearing are very similar to that of most other psittacines, it is noticeable that Spix's chicks have a particularly mild-mannered begging response. Additionally, in comparison to other larger macaws, the chicks are susceptible to gaining too much weight, and a lower fat formula is more suitable. If Spix's Macaws are overfed, they counter-balance this by regurgitating food. We utilize observations of post-feeding regurgitation as an indicator for when to reduce the number of daily feedings.

For the first time, in 2007 one fertile egg was left to hatch under the parents. This embryo was the sibling of 3 others already hatched that season, with 3 others from previous seasons. (Dam is female #4269 listed in Appendix Table A1 & A2) Although the parents were not considered to be totally disease-free – both had a disease transmission risk status as 'yellow' – it was considered a calculated risk to leave this one fertile egg from their second clutch to be hatched and raised parentally. This strategy was adopted due the female's reproductive history. In 3 consecutive seasons, she had produced a total of 18 eggs, and we felt that such intelligent birds would benefit from the stimulus of raising an offspring, and perhaps ensure that they retained an enthusiasm for breeding in subsequent seasons. Additionally, having already produced 6 offspring in 3 years, any additional offspring would not be considered particularly genetically valuable. The nest box was checked daily shortly before, during and after hatch to monitor the progress of the egg / chick, since we were fully prepared to rescue the chick if its progress was less than ideal. Unfortunately, despite the initial encouraging signs of full crops and good weight gains, on day 9 the chick was found to have injuries on its toes, including the complete removal of one toe-nail, caused by parental mutilation. At this point, the chick was removed to the nursery for hand-rearing, where it has since recovered from its injuries and is making good progress.

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In the incubation and hand-rearing rooms we take a number of extra precautions to ensure the safety and welfare of the Spix's Macaw eggs and chicks:

- As a component of the health-screening program, swabs are taken for bacteriological / fungal cultures from the cloaca and buccal cavity of each chick. These swabs are taken at age 3 days, 7 days, 14 days, and every 7 days until two weeks after the chicks have weaned.
- As another disease-prevention measure, no staff is allowed in the Spix's Macaw hand-rearing room if they have been in contact (or in a building) with any other psittacines, unless the member of staff has showered and completely changed their clothes.
- Located in the middle of the Qatari desert, it would be fair to say that Al Wabra does not experience the most reliable electrical supply. Consequently, AWWP has back-up generators to provide power in the occurrence of a power cut. Even so, as soon as there is a power cut to the incubation and hand-rearing rooms, senior members of bird staff receive an automated cell phone message announcing the concern and respond immediately. Similarly, power surges are not uncommon occurrences, so each incubator and brooder is connected to a power surge protector to prevent damage to machines, both acute and chronic.

### Conclusion

Despite the challenges faced by AWWP in breeding Spix's Macaws, significant progress is being made in the propagation and management of the flock. A rigorous program of disease control, monitoring and treatment is limiting the incidence and transmission of clinical disease through the population, with no mortalities since 2005. Although there are still significant hurdles in achieving high levels of fertility and hatchability in the population, strategies to ensure high standards of husbandry, housing and artificial propagation have led to the production of 16 healthy chicks over 4 breeding seasons. Chart 1 displays the progress being made in increasing the population of Spix's Macaws, both at AWWP and throughout official collaborative institutions.

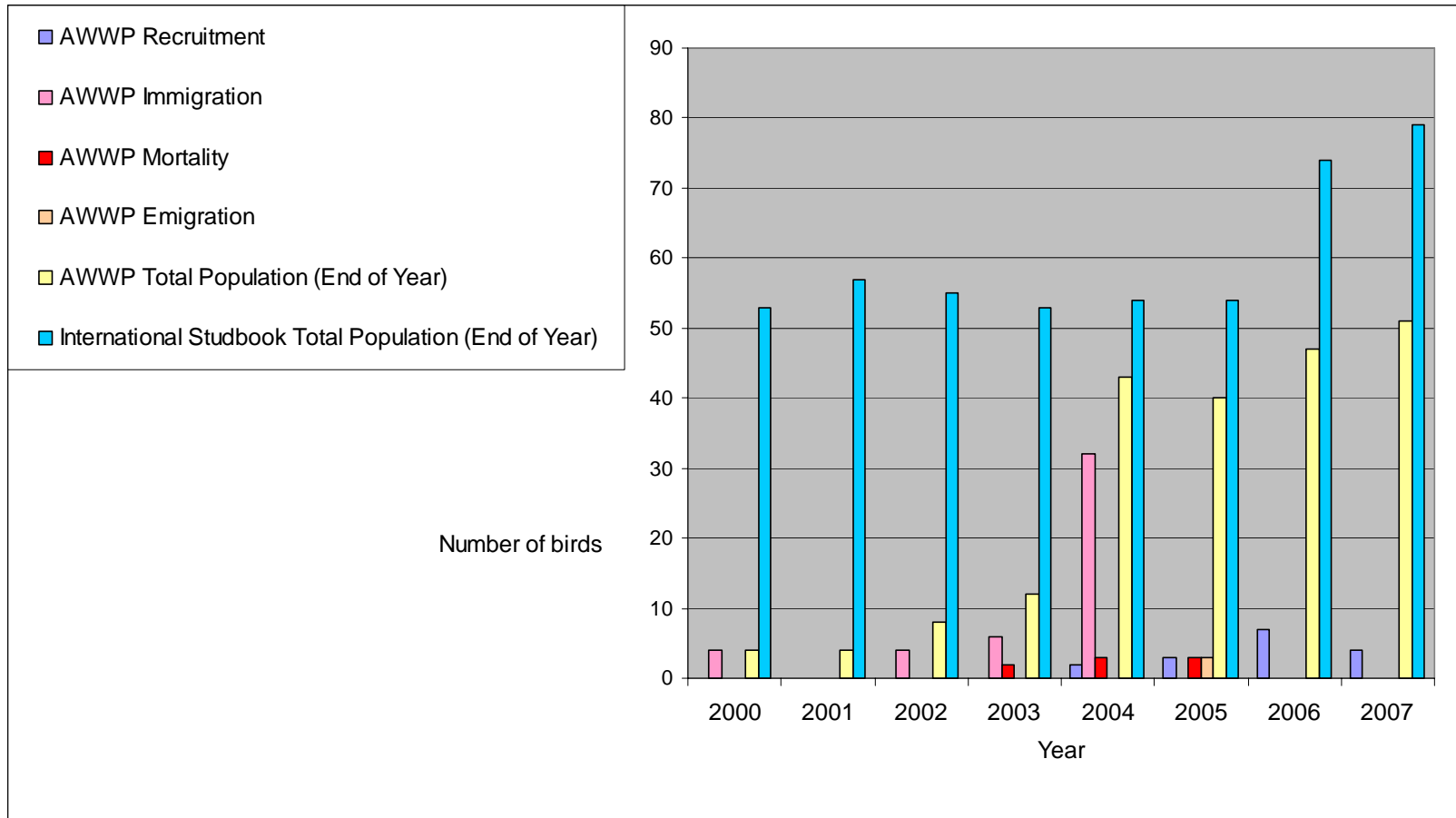
With recently-acquired genetic knowledge, we can look forward to improving our genetic management of the population, both at AWWP and with our collaborators throughout the studbook. Furthermore, as the 16 healthy youngsters are recruited into the breeding population, we hope to enhance our reproductive success. Although the current progress is slow, AWWP is optimizing the husbandry, veterinary care and reproductive management of its flock. We hope to provide a solid foundation for the future of the Spix's Macaw.

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**Chart 1: Historical Overview of the Spix's Macaw Population at AWWP, with comparison to the international studbook population.**



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## Appendix

**Appendix Table 1: Total number of eggs laid in season & percentage confirmed fertility of individual breeding females, 2003-2007**

Breeding female	2003		2004		2005		2006		2007		Total Eggs Laid	Mean % Fertility
	Eggs laid	% Fertility	Eggs laid	% Fertility	Eggs laid	% Fertility	Eggs laid	% Fertility	Eggs laid	% Fertility		
3253	-	-	5	60% (n = 3)	1	0% (n = 0)	-	-	4	75% (n = 3)	10	60% (n = 6)
3254	6	0%	-	-	-	-	-	-	-	-	6	0% (n = 0)
4180			7	0% (n = 0)	7	29% (n = 2)	-	-	-	-	14	14% (n = 2)
4269			-	-	7	14% (n = 1)	4	75% (n = 3)	7	57% (n = 4)	18	44% (n = 8)
4329*			15	80% (n = 12)	10	10% (n = 1)	-	-	-	-	25	52% (n = 13)
4332			9	0% (n = 0)	9	0% (n = 0)	-	-	-	-	18	0% (n = 0)
4336			4	25% (n = 1)	-	-	-	-	-	-	4	25% (n = 1)
4365			-	-	-	-	-	-	6	0% (n = 0)	6	0% (n = 0)
4366			-	-	-	-	-	-	8	0% (n = 0)	8	0% (n = 0)
4369			-	-	-	-	8	87.5% (n = 7)	7	0% (n = 0)	15	47% (n = 7)
<b>Total</b>	<b>6</b>		<b>40</b>		<b>34</b>		<b>12</b>		<b>32</b>		<b>124</b>	
<b>Mean</b>		<b>0% (n = 0)</b>		<b>40% (n = 16)</b>		<b>12% (n = 4)</b>		<b>83% (n = 10)</b>		<b>22% (n = 7)</b>		<b>30% (n = 37)</b>

Note: Pink shading identifies birds maintained in Switzerland; all other birds were maintained in Qatar.



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**Appendix Table 2: Percentage hatchability, number of chicks produced and mean hatch weight of chicks, according to each individual breeding female 2004-2007**

Breeding female	2004		2005		2006		2007		Total Chicks	Mean % Hatch.	Mean chick hatch weight
	% Hatch.	Mean chick hatch weight	% Hatch.	Mean chick hatch weight	% Hatch.	Mean chick hatch weight	% Hatch.	Mean chick hatch weight			
3253	0% (n = 0) (N = 3)	-					0% (n = 0) (N = 3)				
4180	-	-	100% (n = 2) (N = 2)	12.87g		-	-	--	2	100%	12.87g
4269	-	-	100% (n = 1) (N = 1)	11.90g	67% (n = 2) (N = 3)	11.45g	100% (n = 4) (N = 4)	12.98g	7	88%	12.39g
4329	17% (n = 2) (N = 12)	16.27g	0% (n = 0) (N = 1)	-		-		-	2	15%	16.27g
4332	-	-	-	-	-	-	-	-	-	-	-
4336	-	-	-	-	-	-	-	-	-	-	-
4365	-	-	-	-	-	-	-	-	-	-	-
4366	0% (n = 0) (N = 1)	-	-	-	-	-	-	-	-	-	-
4369	-	-	-	-	71% (n = 5) (N = 7)	11.67g	-	-	5	71%	11.67g
<b>Mean</b>	<b>12.5%</b> (n = 2) (N = 16)	<b>16.27g</b>	<b>75%</b> (n = 3) (N = 4)	<b>12.54g</b>	<b>70%</b> (n = 7) (N = 10)	<b>11.61g</b>	<b>57%</b> (n = 4) (N = 7)	<b>12.98g</b>	<b>16</b>	<b>43%</b> (N = 37)	<b>12.71g</b>

% Hatchability: n = number off eggs that hatch; N = number of fertile eggs.

Note: Pink shading identifies birds maintained in Switzerland; all other birds were maintained in Qatar.

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**Appendix Table 3: Egg biometrics of individual breeding females, 2004, 2006 & 2007.**

Breeding female	2004		2006		2007	
	Mean Length (mm)	Mean diameter (mm)	Mean Length (mm)	Mean diameter (mm)	Mean Length (mm)	Mean diameter (mm)
3253	n.d.a.	n.d.a.	-	-	41.42 (N = 4)	30.3 (N = 4)
3254	-	-	-	-	-	-
4180	n.d.a.	n.d.a.	-	-	-	-
4269	-	-	37.8 (N = 2)	29.2 (N = 2)	37.8 (N = 7)	30.2 (N = 7)
4329	40.2 (N = 9)	31.3 (N = 9)	-	-	-	-
4332	41.4 (N = 9)	31.0 (N = 9)	-	-	-	-
4336	39.8 (N = 4)	31.4 (N = 4)	-	-	-	-
4365	-	-	-	-	36.6 (N = 6)	30.3 (N = 6)
4366	-	-	-	-	39.8 (N = 8)	30.0 (N = 8)
4369	-	-	39.8 (N = 4)	28.9 (N = 4)	39.1 (N = 7)	29.6 (N = 7)
<b>Mean</b>	40.7 (N = 22)	31.2 (N = 22)	39.1 (N = 6)	29.03 (N = 6)	38.8 (N = 32)	30.1 (N = 32)

Note: Sample size of eggs (N) reflects number of eggs measured, not necessarily the number of eggs laid by each female.  
n.a. = no data available, although eggs were laid.

Note: Pink shading identifies birds maintained in Switzerland; all other birds were maintained in Qatar.

# AL WABRA WILDLIFE PRESERVATION

Sheikh Saoud Bin Mohd. Bin Ali Al-Thani



**Appendix Table 4: Summary of AWWP Bird Collection, July 2007**

Family	AWWP Order / Group	Number of Species	Number of individuals	Notable species
<i>Psittaciformes</i>	Blue Macaws	3	70	Spix's Macaw; Lear's Macaw.
	Other Macaws	3	22	Blue-throated Macaw; Blue-headed Macaw.
	Other Parrots	3	15	Pesquet's Parrot; Golden Conure.
	Cockatoos	6	16	3 spp of Black Cockatoo.
<i>Passeriformes</i>	Birds of Paradise	6 (7 taxa)	80	2 sub-sp of Greater BOP; 12-Wire BOP.
	Bowerbirds	1	6	Flame Bowerbird.
	Cotingas	1	2	Long-Wattled Umbrella Bird.
<i>Struthionidae</i>	Ratites	1 (2 taxa)	7	Sudanese Red-neck Ostrich.
<i>Pelecaniformes</i>	Pelicans	1	10	
<i>Ciconiiformes</i>	Storks, Ibis & Spoonbills	7	97	Breeding group of Marabou.
<i>Phoenicopteriformes</i>	Flamingos	2	36	
<i>Anseriformes</i>	Waterfowl	2	5	
<i>Falconiformes</i>	Raptors	1	1	
<i>Galliformes</i>	Pheasants & Guineafowl	4	200+	Bulwer's Pheasants; Somali Tufted Guineafowl.
<i>Gruiformes</i>	Cranes & Bustards	3	3	
<i>Pteroclididae</i>	Sandgrouse	3	100+	Chestnut-bellied Sandgrouse.
<i>Columbidae</i>	Pigeons	2	9	Pheasant Pigeon.
<i>Cuculiformes</i>	Turacos	2	9	Violet Turaco.
<i>Coraciiformes</i>	Kingfishers	1	1	
<b>Total</b>		<b>52 (54 taxa)</b>	<b>707</b>	