Veterinary Medicine for Falconry into the 21st Century

A collaboration between the International Association for Falconry and Conservation of Birds of Prey and the Qatari Society of Algannas

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Papers (in the conference order)

FORWARD

Dr. Adrian Lombard, President International Association for Falconry and Conservation of Birds of Prey

The International Association for Falconry and the Conservation of Birds of Prey (IAF) is directed by the objectives listed in our Constitution. These include the call to promote veterinary research into Birds of Prey. Beyond this, it is our intention to establish the IAF, the globally representative organization for Falconry, to be the expert organization with respect to the welfare and management of Falconry Raptors.

This conference has provided an invaluable platform to further both our objective and aim. These proceedings, as the product of the conference, result from the assembly of some of the world's leading raptor veterinarians who have been willing to share their learning and wisdom with both other veterinarians and with falconers.

Our thanks go to all the participants who contributed to the success of this event as well as to the sponsors and supporters which include the Algannas Club of Qatar, the Katara Cultural Village and the Souk Waqif Falconry Hospital. Without their generous and visionary support, this event would have been impossible.

It is our hope that this conference is just the first in an effort to promote the veterinary care of falconry birds.

Adrian Lombard, Fish Hoek, South Africa

INTRODUCTION

Prof. Dr. med. vet. Thomas Richter, IAF Vice-President for Europe

Falconry (defined as taking quarry in its natural state and habitat by means of trained birds of prey), depends on a completely healthy and stress-free bird, physically and psychologically in the best condition and by this it is able to catch its prey. This premise brings a unique and mutually beneficial partnership between the falcon and the falconer. The only way to achieve excellent performance from a falconry bird is to have it in peak fitness and optimal health.

Veterinary medicine is one of the keystones in guaranteeing or restoring that best physical condition if it is done by the best educated veterinarians. In order to bring the highest scientific knowledge to their colleagues who deal with falconry birds, the best experts worldwide gave lessons on recent advances of raptor medicine.

We recommend the proceedings of this outstanding conference, which was enabled by the Qatari Society of Algannas and performed by our highly qualified speakers to everybody who is interested in the freshest information on raptor medicine that one can get.

Novel Diseases in Falcons

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Key words: Enterocytozoon bieneusi, microsporidiosis, cutaneous mycobacteriosis, Acinetobacter baumannii, falcons

Abstract

Novel diseases in falcons have emerged in recent years. Significant abscesses in liver, intestines, kidneys and other organs can be found in falcons that are infected with *Enterocytozoon bieneusi*. Its strain in falcons is 100% identical with the strains identified in humans. Another emerging disease in falcons is the *Acinetobacter baumannii* infection which is one of the most important emerging multi-drug resistant nosocomial infections in humans nowadays. In falcons *Acinetobacter baumannii* was detected in cases of cutaneous mycobacteriosis. Its clinical features include characteristic yellowish lesion in the thoracic and abdominal body walls and inside of thighs as well as highly elevated WBCs, heterophilia, lymphocytopenia, severe anaemia and weight loss.

Enterocytozoon bieneusi Infection

Disease Symptoms

Disease symptoms can be unspecific like sudden death, inappetence, anorexia or severe dehydration. Often heavy Caryospora sp. burden can be found in the faeces of the infected falcons. Underlying diseases can be aspergillosis, bacterial infections, hepatomegaly and nephromegaly.

Diagnosis

The endoscopic examination shows clinically apparent abscesses of intestines, liver and/or kidneys which do not resemble tuberculosis, herpes virus infection or any other known disease. Necropsy reveals multiple yellowish plaques (3 to 5 mm in size) on the intestine where this focal diphtheroid enteritis and colitis involved all intestinal layers from the mucosa to the serosa. Numerous yellowish foci (1-5 mm in diameter) were also seen in the liver, kidneys and rarely in pancreas and spleen (Muller et al., 2008).

Histology of the liver lesions reveals large areas with foamy hepatocytes and bile duct proliferation, fresh necrosis and microabscesses in the adjacent areas. The kidneys show severe diffuse degeneration with pyogranulative inflammation, most tubuli containing protein cylinders. Severe diffuse degeneration with pyogranulative inflammation can be found in the pancreas. The intestine show severe focal pyogranulative to ulcerative enteritis. Immunohistochemistry was positive for microsporidian antigen in granulomatous lesions of liver, kidney and intestine. Microsporidian antigen was identified as brownish stained organisms in the cytoplasma of numerous macrophages surrounding necrotic areas (Muller et al., 2008).

The *Enterocytozoon bieneusi* strain with its human specific Genotype D identified in falcons is 100% identical with the strains previously described in humans and can be confirmed by specific *E. bieneusi* PCR methods (Muller et al. 2008).

Treatment

The treatment is performed with dimetronidazole (Emtryl®) 50mg/kg p.o. once daily for 10 days. Falcons with intestinal abscesses were treated after one week rest again with dimetronidazole (Emtryl®) in the same dosage for another 10 days. Those falcons suffering from intestinal, liver and kidney abscesses were treated additionally with special homeopathic medicines such as Nux vomica®, Mucosa compositum®, Hepar compositum®, Berberis compositum®, Cantharis compositum® depending on the case (Muller, 2007). The intestinal flora was restored with Probiotics® (Vetafarm) given daily over the food after the dimetronidazole therapy was finished (Muller, 2007). In early or moderate disease stages, abscess regression until complete regression can be seen in the follow-up endoscopies after treatment. In the end stage of the *E. bieneusi* infection, the disease is fatal (Muller 2009). Other underlying diseases like coccidiosis or aspergillosis are to be treated accordingly (Muller, 2007).

Causative Pathogen

E. bieneusi was detected for the first time in France in 1985 in an immunosuppressed AIDS patient with diarrhoea and isolated from the jejunum (Desportes et al., 1985). Other risk groups are travellers especially in tropical countries (Lopez-Velez et al., 1999), elderly people and children due to their reduced immune system (Lores et al., 2002). *E. bieneusi* is the smallest microsporidian known to date with a spore size of only 1.2-1.7 µm length (Canning, 1993) which might be the cause why its detection in unstained direct smears fails to diagnose the spores (Muller et al., 2008). In humans this protozoan is the most frequent species followed by *E. intestinalis* as the second most prevalent species out of 14 known microsporidian species causing diarrhoea and systemic disease (Reetz et al., 2002).

Discussion

E. bieneusi is known to be present in domestic animals (Lores 2002) such as rabbits, goats, pigs and dogs (Del Aguila et al. 1999). Infections of birds with *E. bieneusi* were reported for the first time detected in chickens in 2002 (Reetz et al. 2002) and recently in a second avian species, urban pigeons (Haro et al. 2005). In 20% of the pigeons tested, the prevalence of *E. bieneusi* was confirmed by PCR. This finding is even more interesting as falcons are birds of prey which are frequently fed with pigeons. The lack of a transmission barrier of *E. bieneusi* might lead to a possible zoonotic potential (Dengjel 2001). *E. bieneusi* is best detected by PCR methods. The identified genotype D that has been identified in falcons has not been found in any birds so far, but only in humans, macaques and pigs (Muller et al., 2008).

Acintebobacter baumannii Infection

Clinical symptoms

Disease symptoms include various unspecific symptoms, including anorexia, weight loss and not flying well. Some sick falcons are presented only for general examination. However, all falcons have one common disease symptom: cutaneous yellowish-coloured lesions. Those lesions are located on the right and left lower thoracic and abdominal body walls as well as on the inside of both thighs with a prevalence of 94% body wall lesions and 50% thigh lesions. Their sizes range from under 1 cm up to more than 5 cm (Muller et al., 2010). In case of thigh lesions, falcons are not putting full weight on the affected leg. They might also have problems to stretch the affected leg.

Diagnosis

The skin lesions are very typical with regard to location and colouring. However, the definite diagnosis of *A.baumannii* is established with the specific *A.baumannii* PCR of the tissue (Muller et al., 2010).

Acid-fast bacilli were seen in the biopsied tissues and faecal of all falcons tested with Ziehl-Neelsen (ZN). In most cases, large amounts of acid-fast bacilli of up to +++ acid-fast bacilli were detected (Muller et al., 2010).

The haematological blood parameters show highly elevated WBCs, heterophilia, lymphocytopenia, and severe anaemia whereas the blood biochemistry is not meaningful.

Table 1: Mean of haematology results of Gyr-Saker and Gyr-Peregrine hybrid falcons (Muller et al., 2010)

Parameters	Gyr-saker A.baumannii and Mycobacteriosis	Gyr-Saker Reference Values	Gyr-Peregrine A.baumannii and Mycobacteriosis	Gyr-Peregrine Reference Values
RBC(x 10^{12}/l)	2.15	2.18-2.48	2.02	2.13-2.65
Hb (g/dl)	12.60	16.23-19.23	12.23	16.33-19.47
Hct %	38.10	46.91-56.23	34.10	47.25-56.75
MCV (fl)	166.45	200.29-243.49	186.62	194.32-245.08
MCH (pg)	58.40	69.41-83.07	67.48	67.14-84.04
MCHC (g/dl)	35.10	32.85-35.99	36.51	32.95-35.91
WBC(x 10^{9}/l)	29.70	5.28-9.72	31.53	5.28-9.82
Heterophils %	71.00	46.02-53.78	72.90	46.41-53.41
Lymphocytes%	19.90	41.20-47.02	22.14	40.82-47.54
Monocytes%	3.00	2.84-6.00	3.31	2.77-6.03
Eosinophils%	1.00	0.37-2.21	1.26	0.29-2.45
Basophils%	0.50	0.25-0.55	0.56	0-0

In the *Mycobacterium* genus PCR, the vast majority of cases show positive results. Among them all tested positive for *M. avium* and only one showed a positive result for *M. paratuberculosis* (Muller et al., 2010). Most cases are detected in the specific *A. baumannii* PCR which shows best results when tissue material is used. In early disease cases, the specific *A. baumannii* PCR might not be able to detect the pathogen from blood or faeces samples and might then lead in false negative results.

Causative Pathogen

The genus *Acinetobacter* comprises strictly aerobic, gram-negative and non-fermentative bacteria belonging to the family Moraxellaceae. They are widely distributed in the natural environment as well as in hospitals where they can survive on moist or dry surfaces for long time (Schreckenberger et al., 2003).

A. baumannii is the most commonly found *Acinetobacter* species in humans and has emerged as multi-drug resistant pathogen in humans (Schreckenberger et al., 2003). Moreover, it has evolved as one of the most important nosocomial pathogens in the past decade (Villers et al, 1998) particularly in immunosuppressed patients (Schreckenberger et al., 2003). However, its success as emerging pathogen might be based on its ability to integrate large amounts of foreign DNA in its genome (Smith et al, 2007). From 2002 to 2004, *A. baumannii* infections were found in 102 injured American soldiers who served in the Afghanistan and Iraq/Kuwait region. A potential environmental contamination of traumatic injuries might have been an influencing factor (CDC, 2004).

Commercially available microbiology testing systems like Mini-API or Vitek are not successful in the detection of *A. baumannii* (Chang et al., 2005). Identification of *A. baumannii* through ITS sequencing is regarded as reliable methods whereas also the amplified ribosomal DNA (ARDRA) testing is regarded as effective PCR method (Chang et al., 2005). At Abu Dhabi Falcon Hospital, tissue samples of the lesions in all suspected *A. baumannii* cases are tested with the specific *A. baumannii* Real-Time PCR.

In contrast to *A. baumannii* infections, mycobacteriosis is well-described in birds and mainly caused by *Mycobacterium avium* and *Mycobacterium genavense*. Both pathogens are excreted with the faeces (Tell et al., 2002; Lennox, 2002) and affect mainly hepatic and gastrointestinal organ systems (Tell et al., 2001).

Treatment

Due to the potential zoonotic risk of *A. baumannii* , treatment options should be weighed very carefully. In advanced diseases stages, even prolonged treatment of up to 6 months might not result in clearing up the disease and therefore euthanasia should be considered.

Discussion

In veterinary medicine, *A. baumannii* has so far been detected in dogs, cats, horses and wild birds. However, no cutaneous mycobacteriosis lesions in animals and birds were isolated in association with *A. baumannii* (Muller et al., 2010). The time duration till manifestation of mycobacteriosis and *A. baumannii* infection ranges between 3-5 months (Muller et al., 2010). The main common symptoms are the cutaneous lesions. The location of those cutaneous

lesions of the sick falcons is found only as localized lesions on both body walls ranging from the lower thoracic part to the abdominal areas as well as on the inside of left and right thighs . The size is variable and ranged from 0.5 mm up to 5cm. The yellowish lesions are of firm, leathery like consistency (Muller et al,. 2010). Thigh lesions can result in inability to stand properly on the leg or to stretch it.

The haematological changes show unified pattern with strong anaemia, high white blood cell counts, heterophilia and strong lymphocytopenia. Furthermore, basophilia is present and albumin and total protein levels are slightly elevated (Muller et al,. 2010). In falcons, severe bacterial of fungal infections like aspergillosis and pseudomoniasis can cause very elevated WBC and heterophilia associated with lymphocytopenia. It is worth to note that the Gyr-Saker hybrid falcons showed decreased haematological parameters, where among Gyr-Peregrine hybrid falcons infected with *A. baumannii* and mycobacteriosis had higher values (Muller et al,. 2010). In all performed acid-fast bacilli stains bacilli are clearly seen which is highly indicative for a mycobacteriosis and gets confirmed through the PCR results (Muller et al,. 2010).

Despite the fact that *A. baumannii* infections are nosocomial infections that are transmitted frequently in hospital, it could be proved that the infection in falcons did not arise from nosocomial origin (Muller et al., 2010).

Conclusion

The detection of those new diseases in falcons shows that the previously known barrier between human and animal pathogens seems to dissolve and veterinarians have to look beyond veterinary pathogens in modern research.

The detection of *Enterocytozoon bieneusi* in falcons as a third confirmed susceptible avian species raises the question of how many more raptor and avian species might be a host for this microsporidia and how many more falcons might have got infected unnoticed from this disease especially as the genotype D is so far not reported in birds, but in humans, macaques and pigs. Special faecal staining should be added to the routine examinations if a frequent interaction or contact of falcons and free-living pigeons is present. Moreover, in doubtful cases, specific *Enterocytozoon bieneusi* PCR testing should be performed for the suspicious falcon samples (Muller, 2009).

The assumption can be made that the *A. baumannii* infection was a secondary infection in falcons suffering from immune suppression caused by the Mycobacteriosis (Muller et al., 2010). It seems likely that the falcons got infected with *A. baumannii* through contamination from wild birds, possibly through their faeces (Ahmed et al., 2007), which they might have caught while hunting. However, it remains unclear to what extent wild birds are infected with A. baumannii and what might be the likelihood of a possible inter-species transmission.

Moreover, the findings of those new pathogens in falcons raise the question if a possible zoonotic potential of *Enterocytozoon bieneusi* and *Acinetobacter baumannii* exists and to which extent falconers who live in close contact with their falcons might be at risk of a disease transmission from their birds (Muller, 2009; Muller et al., 2010).

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Veterinary Perspectives of Falcon Breeding

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Introduction

Many raptor species are endangered or threatened with extinction and species conservation programs exist. Additionally commercial breeding of raptors, in particular falcons for falconry purpose is common. Successful reproduction of birds of prey in captivity regularly fail or the reproduction rate is low. The reason for this is multiform. Usually management related problems are the most common reason, followed by diseases or infertility. To solve such a problem in a breeding flock a detailed investigation is necessary. The veterinarian plays the most important role in this process as he/she has the capability to perform all necessary detailed investigations. However, a veterinarian in this role needs to understand how to manage a breeding flock and which parts are of special importance. The following manuscript provides a basic introduction. For more detail the reader is directed to further literature (e.g. Lierz, 2008).

Basics in Birds of Prey Reproduction

Birds of Prey are monogamic and reach their sexual maturity usually between 2-6 years. Pairs are very territorial and the bond to their nesting site is strong. The male is around one third smaller than the female and provides the food for the brooding female. Males do brood to a much lesser extend compared to the female. Birds of prey have usually a sibling sexual imprint starting around day 8 after hatch. Purely human hand reared single birds of prey are unable to reproduce naturally, but can be stimulated by man and artificially inseminated. This is usually used for the production of species hybrids. Birds of prey hand reared in groups may be used for natural breeding and sexual stimulation by humans, but parent reared birds are best for natural reproduction.

Birds of prey usually lay 2-4 eggs in one clutch. By removing the eggs before the clutch is completed, the female may be stimulated to lay more eggs (egg pulling). In case the eggs are removed within 2-3 weeks after clutching, a second clutch will be laid.
Breeding birds should be kept in flying cages with a nesting site. In case assisted reproduction techniques are used, imprinted semen donors can be kept by falconry methods.

Assisted Reproduction techniques

In falconry outside Germany hybrid falcons are commonly used. Those hybrids are mixed breeds of two different falcon species, which –under natural circumstances- do not reproduce together. Therefore artificial insemination techniques are used. Breeding birds are imprinted to humans and when they reach sexual maturity the breeder is able to stimulate the bird. Semen is collected from the males by massage methods or by voluntary semen donation. This semen is transferred into the cloaca or the oviduct of a female immediately prior egg- laying (Temple 1972, Lierz 2008).

In several bird of prey breeding facilities eggs are removed and placed in an incubator. Natural incubation in captivity can be risky, especially with inexperienced females as they might leave the nest or damage the eggs. Artificial incubation of bird of prey eggs is not easy and each egg needs to be treated individually. Apart from the temperature (37.2°C – 37.4 °C), the humidity is an important key factor. Each egg should lose between 14%-16% weight during the complete incubation period. Therefore the egg needs to be weighed and humidity adjusted to reach those loss rates. In case alteration is insufficient, the egg shell needs to be manipulated. Additionally vitality of the embryo should be controlled, either by candling or superior by a device which is able to monitor the heart rate (Buddy ® Digital Egg monitor) (Lierz et al., 2006).

Chicks break the egg shell from inside (pipping) at the end of the species specific incubation period. In falcons this is day 30 of incubation. After pipping it still takes 48-50h until hatch is completed and during this time no manipulations should be done. Chicks are than fed earliest 6 h after hatch and usually placed back to the parents between day 6-10 of life, except they are purely hand reared.

Veterinary considerations of bird of prey breeding

Breeding birds of prey include many risk factors that need to be considered. Pairs are in large cages with no direct control of the individual. Especially during the reproduction period disturbances usually interfere with breeding activity. Imprinted single breeding birds are much better to control from the health point of view. However, repeated inseminations do carry an increased risk of diseases of the reproductive organs. Last but not least reproductive behaviour and egg laying is an increased stress to the birds. Birds of prey breeding birds are usually kept in outside aviaries where those birds have contact to the free- ranging population of various birds. Also partners are usually placed together without an intensive health check. Regularly breeders place eggs from other breeders in their incubator or place chicks of different sources together, even to the same pair. All this significantly increases the risk of infectious disease.

Problems in Birds of Prey Reproduction

Infertile clutches

The most common problem in Bird of Prey breeding facilities is infertile eggs. Commonly pair behaviour is not always ideal and despite the owner not seeing a problem, copulation does not occur successful. It needs to be considered that the male as the smaller partner has to approach the larger female and has to fly onto her back. Females might interpret this as aggression and hurt the male. Compared to nature, males cannot escape aggressive behaviours as they are in an aviary. Therefore males must approach the female carefully, offer her food and stimulate her for copulation. Even after an attack from the female, males need to be brave enough to try copulations again and again…. and again. Many males fail this, offer food, demonstrate reproductive behaviour, but do not try to copulate again after one poor experience. Therefore the male represents the key factor in natural reproducing pairs. As food-offer behaviour from the male to the female is important, males must be supported by the breeder. During reproduction period, the pair should be fed several times during the day with high quality food.

Secondly infertility of the male is a common reason. Infections (etc. Salmonella sp., Chlamydia sp., Mycoplasma sp.) involving the reproductive tract, environmental toxins (etc. wood protecting paint, heavy metals, pesticides, mycotoxins), medications (coccidiostatica- e.g. given to the feed animals) or a vitamin deficiency (Vitamine E, A) are possible reasons. In cases where infertility of a male is suspected a detailed spermatological investigation (e.g. motility, PH, live/death rate, sperm morphology) should be performed. It must be considered that the semen of falcons contains so called “Round bodies” (RB) which are a normal structure, but not found in all avian species. In falcons the number of RB can be high despite their function is presently unknown (Fischer et al, 2011b). Reference values are available for the different falcon species (Fischer et al., 2011a), but not for all birds of prey species. In such cases the comparison of ejaculate parameters from the investigated male with proven breeding males is useful. To date spermatological investigations can be supported by computer assisted semen analysis (CASA) which provides additional very useful information (Fischer et al., 2001b). Last but not least functional spermatological test, such as the perivitelline membrane penetration test (Krohn et al. 2012) are very helpful in investigating infertile males which demonstrates motile semen. Last but not least electron microscopical investigations of individual spermatozoa (Schneider et al, 2013) assist in the determination of the reason for infertility.

Additionally a detailed endoscopic investigation of the reproductive tract is recommended involving a testicle biopsy in case the spermatological values or the endoscopic appearance of the testicle are altered.

Last but not least infertile clutches occur after artificial insemination with contaminated semen. Especially when urate or faecal contamination decreases spermatozoa vitality enormously.

Reduced egg quality

Alterations of the egg shell occur if the female faces stressful events. Those might come from outside or from disturbed pair behaviour. Calcium deficiencies also lead to thin egg shells. Reasons are low Calcium content or imbalanced Calcium/ Phosphorus rate in the food, Vitamin-D deficiency or intestinal- or kidney disorders. Last but not least diseases of the females reproductive tract, such as oophoritis, salpingitis or cloacitis need to be considered.

Reduced hatching rate

Most commonly a reduced hatching rate is caused by incubation management failure. In particular wrong temperatures (check the thermometer!) and/ or not controlling the weight loss of each egg are causes. Additionally poor incubation hygiene and malpositioning of embryos in the eggs also reduce hatching rate.

It needs to be considered that an egg is a closed system. Once the egg is laid, nothing can be added or removed. Therefore the feeding management of the parents, especially the female, is of major importance for a satisfying hatching rate. As the egg follicle starts growing approximately six weeks prior its ovulation and the egg yolk contains most of the nutritional ingredients for the growing embryo, high quality, vitamin (E, B2, D3) enriched food must be supplied a long time before the first reproductive activity is visible. This is in many cases not considered by the breeder.

Additionally vertically transmitted pathogens need to be considered. Regularly infected females are clinically healthy, but carriers and infected embryos die. The same occurs with environmental toxins (pesticides, mycotoxins), which may not affect the female clinically, but are transmitted via the egg yolk and affect the embryo severely.

The investigation of a decreased hatching rate involves a detailed judgement of the breeding and feeding management and a post mortem examination of the egg including evaluation of the time of death of the embryo. Common reasons for early embryonic death are egg transport, egg storage prior to incubation, severely wrong incubation temperature, microbiological egg contamination or environmental toxins. Late embryonic death usually occurs after malnutrition of the parents, vertically transmitted pathogens,

failure in incubation management such as deficient egg turning, slightly wrong incubation temperature, insufficient or increased egg weight loss.

First of all the incubator needs to be controlled, all instruments must work correctly, and swabs for microbiological investigations need to be taken to control incubation hygiene. Investigation of the egg and embryo should involve a microbiological examination of the egg yolk. The egg yolk membrane and the trachea of the embryo should be taken to investigate for mycoplasmas, the egg shell for detection of salmonella, liver and kidney of the embryo should be stored for virological examination and the complete embryo should than be placed in formalin and send for histopathological examination.

Veterinary Management of Breeding Birds

Breeding Birds demand special attention, not only because of their high value, but also due to their increased health risk (see above). On a regular basis (every 3-6 month) a faecal sample should be taken and investigated for parasites and *Salmonella* spp. At least once in a year the birds should be investigated in detail. This involves a swab for detection of *Chlamydia* sp., and a stress test (Chitty and Lierz, 2008), investigating the function of the respiratory tract. In cases where the stress test demonstrates alterations, an endoscopic evaluation of the bird should be performed. A blood sample should be taken to investigate the antibody level against Paramyxovirus-1 and Avian Influenza Virus H5 and H7, blood chemistry to investigate liver and kidney function, haematology to detect chronic diseases and determination of the vitamin and trace element level, especially if a nutritional imbalance is suspected. Last but not least treatments (e.g. against parasites) or prophylactic measures such as vaccinations (against Paramyxovirus-1 (PMV-1) and avian Influenza (AIV) (H5/H7) can be done at that time. It has been demonstrated in vaccination and challenge studies, that vaccination against H5 using inactivated vaccine is able to protect the birds completely from clinical disease (Lierz et al., 2007). This is especially important for falcons which are clinically very susceptible to PMV-1 and highly pathogenic AIV (H5N1).

In conclusion: Breeding birds of prey in captivity is a complex system. Especially since the basics of management and behaviour of the birds are not fully understood by many owners. Regularly, reproductive success rates of 40%-50% (hatched chicks to laid eggs) are considered as a success, which is usually well below natural reproduction rate (>80%), not to mention pairs which do not lay at all. Therefore the role of a veterinarian in a breeding facility cannot be overestimated and increasing the success rate is usually possible. The veterinarian plays a key role in increasing the success of such facilities and the health of the breeding birds.

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Lead poisoning of wild raptors from ingestion of lead bullets and shot Veterinary treatment and activities for prevention

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Fig.1 Steller's Sea Eagle and White-tailed Eagle wintering in Hokkaido Japan

The Steller's Sea Eagle (*Haliaeetus pelagicus*) and the White-tailed Eagle (*H.albicilla*) are the largest Sea Eagles in the world, and breed almost exclusively in the coastal regions of eastern Russia. Total population of the Steller's Sea Eagle is estimated at 5000 to 6000 individuals. These eagles winter in large numbers in northern Japan, on the island of Hokkaido. Lead poisoning of Steller's Sea Eagle in Japan was first confirmed in 1996. Since then more than 150 Steller's and White-tailed eagles have been diagnosed as lead poisoning fatalities. The primary cause of poisoning in eagles is by feeding on lead-contaminated deer carcasses. If hunting continues, as in the past, using lead bullets, this will unquestionably exacerbate the eagle poisoning problem. Tradition and law in Japan allow hunters to remove the desirable meat from animals and abandon the rest of the carcass in the field. Deer carcasses have now become a major food source for these wintering eagle populations.

Steller's Sea Eagles normally weigh 6 to 8 kilograms, but individuals killed by lead show severe weight loss. Due to malnutrition, wasting of the pectoral muscles and reduced amounts of visceral fat were conspicuous. Green diarrhoea similar to that observed among lead-poisoned waterfowl was observed in each case. Atrophy of livers and distended gallbladders filled with bile was commonly observed. Liver lead values of 9.5－89 ppm (wet-weight) were demonstrated that these eagles were killed by lead. Necropsies and radiographs have revealed pieces of lead from rifle bullets and from shotgun slugs to be present in the digestive tracts of poisoned eagles.

Reacting to the eagle poisoning issue, Hokkaido authorities have regulated the use of lead rifle bullets since winter 2000. The Ministry of the Environment also announced that hunters would be required to use non-toxic rifle bullets or shotgun slugs from winter 2001. In addition, the same regulation for the bear hunting has started from year 2004. However, these regulations are limited and only apply to the island of Hokkaido, and depend largely on cooperation from hunters. Heavy snowfall in Hokkaido makes it difficult to police hunting areas and ensure compliance with the lead ban. A nationwide ban on the use of lead ammunition for all types of hunting is the only way to solve the problem of lead poisoning of eagles.

Lead poisoning caused by lead ammunition

Lead poisoning in avian species had been reported in Japan previously. However, it was mainly in the case of waterfowl, which was caused by the ingestion of the fishing weight or lead pellets. Waterfowl have the habit of swallowing a small stone with food as assistance to digestion in the stomach. Water fowl ingest the lead fishing weights or lead pellets used in water fowl hunting, in mistake for these small stones. The lead poisoned or hit waterfowls are sometimes the cause of secondary poisoning in raptors which tend to prey on them.

150 or more Steller's and White-tailed eagles have died up to the present since the first detection of the lead poisoned Steller's Sea Eagle in 1996 at Abashiri Hokkaido. The main cause of those cases was the lead rifle bullet and slug used in Sika Deer hunting. Tradition and law in Japan allow hunters to remove the desirable meat from animals and to abandon the rest of the carcass in the field. A number of lead fragments remain in the body of the target, and these could be ingested by the raptors when they scavenge the carcasses. In spite of these situations, deer carcasses have now become a major food source for these wintering eagle populations.

In 1998, the Hokkaido government authorities announced a radical deer population control program, to reduce the feeding damage caused by Sika Deer. This would cull the herd in eastern Hokkaido from the current 200,000 animals to 30,000 within three years. As a result, the remains (carcasses) of Sika Deer left by the hunters came to be seen. The number of Sika deer which had been shot and died later was also greatly increased. The soft tissue was exposed at

Fig.2 A White-tailed eagle scavenging a deer carcass

the shot part of the deer carcasses and became a convenient part for birds that tried to consume it.

Lead poisoning in sea eagles is characterized by the high mortality of the adult birds, those that have reached sexual maturity. According to field observation, adult eagles that have strong power shove other birds out of the way and consequentially they are at a high risk of consuming the meat that contains the largest amount of lead fragments. Older eagles, in which the mortality ratio must usually be low, have been dying at a higher rate than the young birds in relation to lead poisoning. Lead poisoning has an impact not only on the increase in mortality, but also on the decrease of the next generation. Moreover, the number of lead poisoned eagles that are collected is just a tip of an iceberg. It is thought that far more eagle carcasses exist in the mountains in midwinter, where no one might visit. It is said that the actual casualties by lead poisoning is far greater than the number found. Even if the amount of ingested lead was not fatal, the toxic substance deadens the action and reaction times of the eagle and as a result it contributes to supplementary causes of death, such as a traffic accident. The impact of lead is immeasurable, since no one knows how many individuals have died during their migration route and in their breeding grounds: the Russian far east. It can be said that the population control of Sika Deer that Hokkaido agency did as a wildlife management, has lead to the ironic result of promoting a very serious negative impact to endangered sea eagles.

Fig.3 Blood transfusion to a White-tailed Eagle

Rescue and treatment of lead poisoned individual

Rescued eagle were occasionally carried to the nearest zoo etc., until it turned out that the common occurrence of eagle death was a lead poisoning. In lead poisoning, prompt treatment becomes an important key to lifesaving. This is because the toxicity of lead is very high and its influence is markedly seen especially in avian cases. In addition, dissolution and the absorption of lead are rapid in birds of prey because gastric-acid secretion is high. Because of this it is thought that the influence of lead is even greater than other birds. Lead poisoning generally brings on digestive symptom such as colic, vomiting and asitia. Lead poisoning also has an influence on hematopoietic tissue, appearing as a symptom of clinical importance. The haemoglobin count in the red blood cells decreases by the obstruction of the haeme synthesis caused by the lead, this bring a critical anaemia. Moreover, lead poisoning causes functional disorder of the liver and the kidney and has adverse effects on the central and the peripheral nerve. The side effect of the antidote to the lead used as treatment is also strong. Therefore, it is necessary to examine the administering method and the amount considering the density of lead in the individual. Because it was necessary to use specialized equipment to measure the concentration levels of lead, diagnosing lead poisoning was not easily done in every case.

As a response to the frequent occurrence of raptor lead poisoning the Japanese Ministry of the Environment, together with the Hokkaido local agency, decided to centralize the reception of the living and dead birds to the Kushiro Shitsugen Wildlife Center, where the veterinary hospital of the Institute for Raptor Biomedicine Japan exists. The utilization of a Lead Care System (ESA inc.) that can measure lead concentration very quickly by little blood sample (0.005 ml) and the collaboration with the Hokkaido Institute of Public Health contributes to a fast diagnosis. Ca-EDTA is sold as an injection and as oral medication in Japan. When high density of lead is confirmed as a result of the blood test, both routes of administration have been used under the regimen to consider side effects and the re-increasing of blood lead concentration. The regimens of Ca-EDTA are, 15 mg /kg/day PO+ 40 mg/kg/day IV or IM or IO in the initial treatment, and 40 mg/kg/day PO in continuation therapy.

Blood transfusion is also an effective treatment, especially for emergency procedure in heavy and severe poisoning. We usually transfuse whole blood (heparinized) when the patient PCV has reduced to 15 % or less. The blood donor should be a non releasable birds (with sequelae) of the same species as the recipient. The donor should be in a good health condition (of course with low blood lead level) and the cross match test (recipient plasma/donor blood cell, recipient blood cell/donor plasma) must be performed prior to transfusion. Transfusion of blood must be performed by IV or IO. (injection or infusion), amount of 1 to 2% of body weight (nearly 10 to 20 % of the total blood volume of the individual), administration once a week.

The criterion of the lead exposure in raptors had been settled as below, by using examples from the one of the water fowl;

Hepatic level
< 0.2 ppm : normal range
0.2 – 2 ppm : high exposure
2 ppm < : lead poisoning

Blood level
< 0.1 ppm : normal range (The obstruction of the enzyme level has reported at 0.1 ppm.)
0.1 – 0.6 ppm : high exposure
0.6 < ppm : lead poisoning

It is important to consider that lead in blood distributes mainly in the red blood cell. Therefore PCV (Packed Cell Volume) strongly effects the lead concentration value in whole blood. The individual which has fallen into anaemia due to the effects of the lead poisoning sometimes only shows normal or slightly higher value of lead, at the inspection of lead concentration in whole blood. As the result, the criterion of the lead mentioned above, is effective only to nonanemic individuals.

Among the individuals (alive and dead) brought to the Wildlife Center, there are some cases that have not obviously diagnosed as the lead poisoning, but showed high lead ratio in blood in spite of other causes of accident or sickness. Even among the individuals, that had a traffic accident (collision with vehicle or train), electrocution, many cases shown high concentration of lead in the blood or organs. Now, eagles used to preying on the carcass of deer are well attracted to the road-kill fatalities that can be found near the road or railroad. Any eagle already suffering from dysmobility due to lead ingestion could easily in turn be hit by a car or train when scavenging road kill.

Fig.4 Dead bodies of lead poisoned Steller's and White-tailed Eagles

Activity of a civic group

Since the spring of 1997, current thinking is that most of the lead poisoning in large size raptors is caused by the ingestion of lead ammunition. In July 1998, the Hokkaido agency formally announced that the lead bullet fragments remain in the body of shot Sika Deer. After that, public opinion began to move greatly towards advocating prevention of the lead poisoning. However, lead poisoning victims still kept. In the winter of 1998-1999, 26 Steller's and White-tailed Eagles were found dead of lead poisoning. As the total number of eagle carcass found this winter was 33, 78 % of them were caused by lead poisoning.

In July 1998, veterinarians living in the eastern part of Hokkaido took a leading part in establishing a civic group "Eagle Lead Poisoning Network". Citizens including students, teachers, company employees, hunters and civil servants have participated in the group activities. They started to act for the prevention of lead poisoning, keeping contact with relevant organizations. The activity on the network divided roughly as shown below.

1) **Investigation of large size raptors in Hokkaido**

The purpose of the field investigation is to figure out the situation of wintering eagles that have been recently moved toward inland from the previous coastal habitats and understand the cause-and-effect relationships between lead poisoning. By making this clear it should be possible to estimate the damage prediction of lead poisoning and take concrete and effective measures. As the main investigation item, the distribution and number of Steller's and White-tailed Eagle, information about abnormal (may be poisoned) individuals, the sites of abandoned deer carcasses and the eagle dependence on those the hunting remains. Whenever sick or dead eagles were found during the field work we collected them and brought them to the Wildlife Center. In addition, abandoned deer carcasses were buried under the ground or transported to a Deer Carcass Collection Box, sited by the local government, whenever possible. As for areas where the box does not exist, deer carcasses were cleared away to the waste facility.

2) **Investigation to understand lead poisoning occurrence and the generation environment**

It is necessary to examine closely the injured and sick individual, as well as to do the post mortem examination for the dead body, to correctly understand the influence of the lead poisoning on population. Therefore, veterinarians and veterinary students made some exclusive veterinary examination such as autopsy, X-ray examination, concentration measurement of lead, and also asked the Hokkaido Institute of Public Health to detect the origin of lead using isotopic ratio examination. In addition, to recognize the state of the lead poisoning indirectly, lead measurement of the faecal sample and X-ray examination of the pellets collected in the field have been attempted.

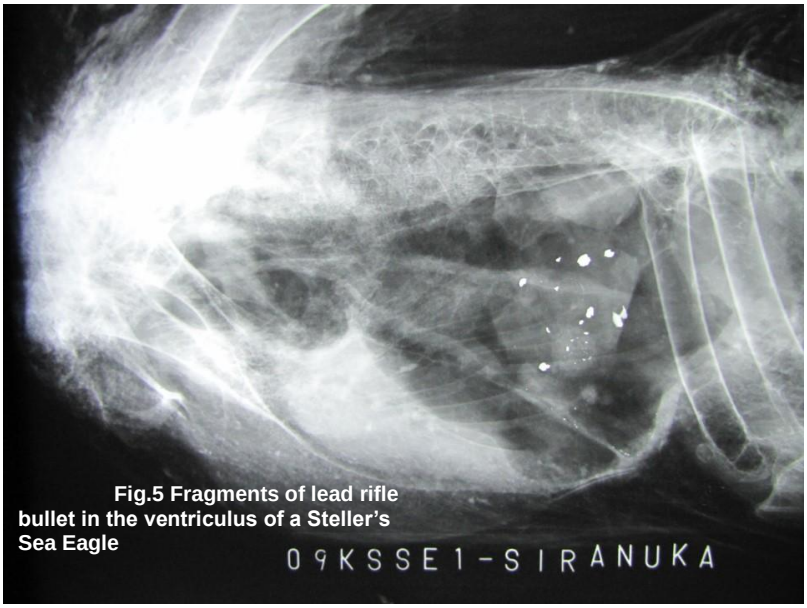


Fig.5 Fragments of lead rifle bullet in the ventriculus of a Steller's Sea Eagle

Investigations of the bullets that remain inside the deer carcasses have been done with collaboration from Hokkaido local agency. This is a project to collect the sample from abandoned deer carcass, detect the contamination of lead pieces or fragments, specify the metal from their shape and characteristics, to make clear the presence of the lead pollutant in the wintering habitat of sea eagles. The sample collection has been done in the hunting field of eastern Hokkaido and when a fresh deer carcass without feeding damage has been found, the soft tissue around the impact area (shot area) was been cut off to the size of 30-50 cm square. Collected samples were closely examined by X-ray and when the presence of the metallic substance was detected it was isolated to verify the detail and origin.

This recent investigation clarified the presence of lead contaminated deer carcasses, even after the governmental ban of lead ammunition in Hokkaido. Documentary research and reviews of the preserved specimens have been carried out to search for buried cases of lead poisoning. As a result, some cases of lead poisoning have been rediscovered among samples that had been diagnosed as starvation.

3) **Improvement of the wintering environment**

The patrol of the hunting ground was frequently done to prevent raptor lead poisoning by shoreline operation. Removal actions of abandoned Sika Deer were executed. In around 1997, many remains of hunting activities were often left on the snow ground. Hunters were still removing the desirable meat from animals and abandoning the rest of the carcass (skin, bone, intestine, and the damaged part) in the field. In addition, most of the carcasses were found near the forest road or clearing, were the hunters can easily load in the game to their cars. Generally, a hunter picks out the intestines from the game immediately, to prevent the door transmission toward the edible part. Isolated intestine were often left in the field and in many cases the lead fragment spread out toward the visceral organs and this was an important lead polluter. Even among the hunters with good sense, a tendency to leave the internal organs in the hunting field was observed. Even though the understanding of the lead poisoning problem grows, publicity of a correct preventive plan has remained a big problem.

On forest roads where the waste was particularly abundant, volunteers loaded a truck with dead deer and transported toward the disposal field. In the worst case, 1 ton of deer carcasses were collected at one forest road during one day's cleaning activity. In due course, these activities received publicity and the government and hunting association started to express concern. The habit of dumping carcasses has gradually changed.

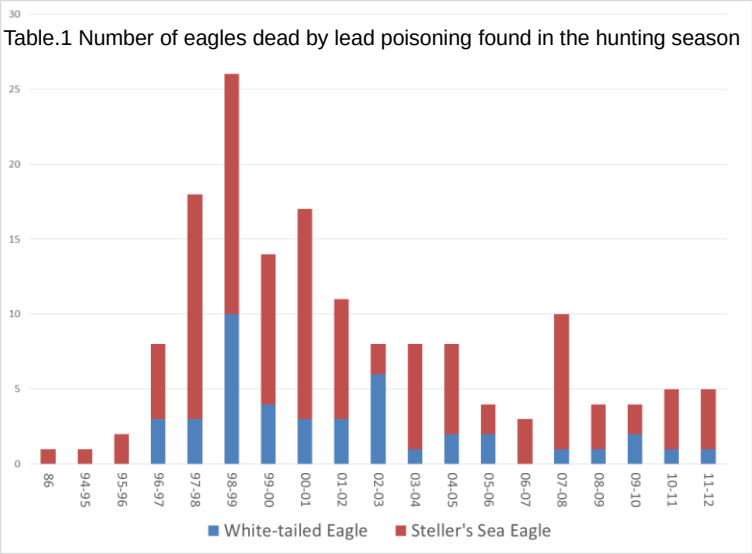
4) **Activity to promote the shift to nontoxic bullets**

Although it is well know that it is a toxic substance, due to its characteristics of softness (easy to process) and high specific gravity, lead has been used from long ago. Bullets and slugs are heavily used for hunting activities in Japan. Most them made of lead and imported from abroad. Most lead poisoning in Steller's Sea Eagle and White-tailed Eagle has been caused by the lead rifle bullets used for Sika deer hunting. There are in existence specialized bullets that will not fragment, copper bullets (ex: Barnes X-bullet) and lead core bullets coated by copper (Winchester Fail Safe bullet). These are all well known and sold as bullets that do not expose lead to the surface after impact on the target. At the time when the lead poisoning of the eagles became a serious problem in Hokkaido, although the warhead of the X-bullet was available, it was almost impossible to get it as the live cartridge in Japan. Therefore, if some hunter wanted to use the copper bullet, it was necessary to make them use an expensive reloading machine as well. To improve this situation, the Network bought a complete set for reloading and loaned it to the local hunting association.

Correspondence of the administration

Reacting to the eagle poisoning issue, the Hokkaido local government has regulated the use of lead rifle bullets for Sika deer hunting since winter 2000. In addition, the government announced that hunters would be required to use non-toxic rifle bullets or shotgun slugs for Sika deer hunting from winter 2001. In 2003, the restriction of the abandonment of game was announced. The regulation of lead rifle bullets and shotgun slugs for all big game (including the Brown bear) hunting started from winter 2004. However, this restriction is limited to Hokkaido Island. The regulation of the use of lead shotgun pellets for waterfowl hunting, is only present as a legal restriction in certain limited areas (or prefectures). Many hunters come from outside of Hokkaido, every year. Lead bullets are legally usable outside Hokkaido, so it is difficult to verify if all foreign hunters change their bullet to the non-toxic ones in Hokkaido Island.

Table.1 Number of eagles dead by lead poisoning found in the hunting season



Starting from the time when the eagle lead poisoning began to appear as a serious problem, the local authority began to settle the "garbage box" in the hunting field, as a solution to decrease the amount of abandoned deer carcass and asked hunters to bring their game remains there. In spite of this, the number of the dead deer in the hunting field has not decreased significantly. In spite of the population control hunting being carried out after the hunting season, the garbage boxes were removed soon after the end of the official hunting season. From 2003 the abandonment of hunting remains has been prohibited. This regulation was put in force not only to prevent lead poisoning, but also to avoid attracting brown bears.

The occurrence of lead poisoning in eagles: conclusions

Lead poisoning of Steller's Sea Eagle in Japan was first confirmed in 1996. In this case, a lead shot for waterfowl hunting was found in the ventriculus of the eagle. The first case of eagle lead poisoning caused by lead bullet, used in Sika deer hunting, was confirmed in 1997. After that time, due to the investigation of preserved samples, it turned out that the lead poisoning of the eagle was already generated in 1986. 18 eagles (15 Steller's and 3 White-tailed) were confirmed lead poisoned in winter 1997-98, 26 (16 Steller's and 10 White-tailed) in winter 1998-99. Afterwards, the numbers of lead poisoning showed a slight decrease, but in fact, the collection rate will greatly depend on the number of people who enter the mountain area and also on the situation of the snowfall. In 2003, 2 cases of lead poisoning in Mountain Hawk Eagle (Spisaetus nipalensis orientalis) were discovered. This indicates that lead poisoning caused by lead ammunition is now spreading out widely among the numerous raptors species.

Finally, all kinds of lead ammunition for all big game hunting have been banned from 2004 in Hokkaido. In spite of this, lead poisoning of eagles still continues. 6 Steller's and 2 White-tailed eagles have been found as victims of lead in the winter of 2004-2005. 9 Steller's and 1 White-tailed eagle in the winter of 2007-08 were found poisoned (Table.1) . These results prove the presence of noncompliant hunters.

A present restriction prohibits the use of lead bullets, but it does not extend to its circulation (sales and purchase) and any ownership. In addition, it is difficult to catch the offender red-handed. These seem big factors in prolonging this problem. It is unreal to expect perfect management leading to the resolution of this question, especially in this deep mountainous region during the severe winter period. However, if the police come frequently to the hunting field, collect samples of the hit-point from the game and examine for the presence of lead fragments, the users of lead ammunition will certainly decrease a lot.

Lead poisoning of eagles caused by the ingestion of lead shot used for waterfowl hunting was known from the past. This occurs when raptors prey (or scavenge) on waterfowl containing lead (ingested or shot or lead poisoned) and so become secondary lead poisoned. The Steller's Sea Eagle and White-tailed eagle live together with waterfowl in the water side (coastal, lake side, river side) in Hokkaido. In this situation, the eagles are likely to prey on the lead contaminated waterfowl and become poisoned. Without a strict regulation of all lead shot this is exacerbating the deer carcase problem. A nationwide ban on all lead ammunition is the only way to solve the problem of raptor lead poisoning. It is extremely important to closely investigate the generation status, not only in Hokkaido but all over the country. It is hoped that the elimination of lead poisoning is achieved as soon as possible, with the cooperation of the administration, hunter and civilian.

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Injuries and Diseases of Falcons Related to Falconry Utilization

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Birds of prey used for falconry can suffer from specific diseases and injuries related to falconry handling and from mistakes in husbandry and management in captivity. Avian veterinarians treating such patients can benefit from knowledge of how falconry birds are trained, fed and housed by falconers. There are a few common recurrent problems which falconers can face while training their birds. Also the community of veterinarians specializing in raptor is increasing and beginner falconers can be advised by veterinarians on how to avoid or prevent the problems specific to raptors used in falconry.

There are specific problems related to different species of falconry birds. Different problems occur in hawks, eagles or falcons. These problems can be also specific if the patient is wild trapped bird or captive bred, even an imprinted bird. In wild birds, but also in parent reared captive birds just removed from the pen, the first problems can be triggered by bad handling and intensive stress in the first days when falconry training starts. Aspergillosis is the major problem. Later if food is refused due to high body condition and high weight, dehydration can lead to kidney damage and gout. If the process of taming is slow, birds can damage themselves while getting used to falconry equipment like perches, jesses, hoods and can damage themselves if kept on hard floor. Specific injuries like keel and wing traumas, jesses strangulation are specifically seen during this period.

Later on in the training period the most critical times are the time of the first flight and the time of the first kill. The reason is that the bird's condition is its lowest at this moment. Intensive hunger emphasized by the predation instinct forces the bird into risky flights which can lead to fractures of wings, legs or head traumas if bird crashes into fencing and barriers. Also the electrocution of birds tired in the chase occurs most frequently during part of falconry training. This period brings also a risk of specific diseases linked to the first kill or to the first good rich food after a period of hunger and chronic dehydration. Veterinarians who frequently treat falconry birds often call this phenomenon the „Disease of the first prey“. The cause of this problem is overfeeding the bird on its first kill. This extra large reward is manifested in a full crop food that cannot be properly digested by a dehydrated bird. Dehydration can be caused by weight reduction when food deprivation also equals water deprivation: birds of prey rarely drink enough to cover their daily water requirements. The problem can be even greater if the meat of the first prey contains too much fat. The liver, pancreas and other secretory glands in the digestive system cannot produce sufficient digestive enzymes to digest a full crop meal so soon after a period of undernourishment and regression of secretory function.

Sour crop, and later crop stasis, are the consequently occurring medical problems. Later changes of the pH in the digestive tract can lead to disbacteriosis and in the worst cases, to clostridia enterotoxaemia. Evacuation of the crop, gastric flush, intensive fluid therapy by i.v. and s.c. fluids administration are the emergency procedures. Similar problems occur also if falcons are fed food contaminated by bacterial toxins. The most common source of contamination is repeatedly defrosted meat, one day old chicken which cooled down slowly or with infected yolk sacks where toxins accumulated. Falcons affected by this will, shortly after feeding, manifest central nervous signs and can be found paralyzed by the perch.

Respiratory problems of falconry birds:

Sinusitis is a well known clinical problem regularly affecting birds in captivity of different species. In raptor species this symptom is diagnosed most commonly in goshawks and sparrow hawks, but cases in falcons and eagles have been recorded as well. In raptor species used for hunting the onset of clinical signs occur early, as the owner notice a “'noisy breathing" immediately after the flight and exercise. Exotic birds usually manifest discharge from the sinuses which sticks to the feathers on the back of the birds. In 70 percent of cases the clinical symptom manifest only after exercise, this can be a forced flight in an aviary or when a so called stress test is applied.

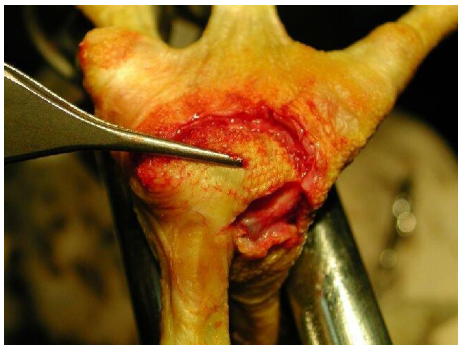
A stress test to an avian veterinarian is a forced jump from the glove while a bird is tied on with a leash. This forces the bird into heavy breathing and manifesting of the typical symptoms for different diagnoses. It is important to exclude tracheal obstruction, aspergillosis or lung oedema caused by clostridial toxins, open beak breathing, noise from the choanal area or filling up/pumping the supra and infraorbital sinuses. These cases are the easiest to treat and a trans choanal flush with saline solution 2-3 times a week usually unblock the sinus and the patient recovers. Trans-choanal flushing can be used in awake birds, but Isofluran anaesthesia makes all procedure easier .The bird is held head down with open beak and 10-20 cc saline is flushed through nares and collected from the choanal opening in a Petri dish. Harvested material can be used for cytology and for further decisions if antibiotics or other disinfectant like F10 is added in next flushing solution. These cases have no significant changes in biochemical and haematological panel. As a preventative measure single dose vitamin A is applied. Application of vitamin A is more important in birds of prey; we see more of sinusitis in raptors that are kept on frozen food. Long term freezing decreases the vitamin A content in meat. Sinusitis symptoms are also more frequent in bird eating species like goshawks, sparrowhawks and peregrine falcons , which require daily fresh meet . In exotic species long term storage of a purely commercial diet can also play an important part.

Most severe cases manifest by extensive swelling in the periocular region. Choanal culture swabs were usually positive in resistant *Pseudomonas sp.* or *E.coli.* In raptors fed on pigeon or chicken meat *Mycoplasma* infection should be excluded. Treatment protocol except the trans choanal

flush also requires sinus perforation and debridement and flushing of the sinus content. This opening -wound placed on unfeathered part in the periocular region heals very fast and needs to be refreshed during regular flushing.

The author is presenting a comparison of contrast radiography of sinuses with the anatomical structures in the rostral region of birds and discussing the surgical difficulties of the approach to all closed cavities. A solution in most severe blocked cases is a trans-rostral endoscopy of the infraorbital sinus cavity . This procedure opens the most ventral chamber of the sinus, enabling visualization as well as application of appropriate antibiotic . Culture swabs are taken directly from the infected sinus and not from choanal opening with the mixed flora of the beak cavity. The limitation of the TRSE-Trans rostral sinus endoscopy might be the size of instrumentation and the anatomical limitation of some species. Aspergillosis is the most feared respiratory problem in falconry birds and leads to permanent fitness deprivation and limits any falconry utilization of the trained bird. Tracheal, pulmonal and airsaccular lesion can be diagnosed. Endoscopy is considered as the only relevant diagnostic procedure to identify extend and prognosis. This lesion can have different specific pathoanatomical manifestations from case to case and even an experienced endoscopist can only objectively state the appropriate prognosis. Tracheal and pulmonal lesion are the cause of acute, severe obstructive dyspnea. They can be visualized by tracheoscopy or by a retrocaudal approach through the ostium from the caudal thoracic air sac, approaching the tracheal bifurcation via the most lateral dorzobronchy.

Traumatic injuries of talons and beak: this is very painful and performance-limiting injury for any falconry bird. Predisposing factors for this are overgrown talon length, a partial fracture or a complete torn off distal phalange which occurs if bird hits the lure or its prey very hard. Treatment consists of lateral compression of the toe, disinfection of the distal phalange and applying a cyanoacrylate glue/talcum powder mixture or an epoxy glue cap. After 6 to 8 months a new horn of talon from the germinative corium will push the cap out. Similar material is used to correct a cracked beak. Electric dremler is used to form the physiological shape of the beak. Deformations of the beak are frequent in older gyr and gyr hybrid falcons due to lack of bone content in food. Cracks of the lateral side of beak are common in peregrine falcons; biting tail mounts, bells and jess can worsen the cracks. Traumatic or infectious damage of the ceroma can lead to permanent beak damage. Overgrown talons can puncture the sole of the feet causing septic arthritis or tendosinovitis. This lesion is treatable much easier than the typical falconry bird's lesion, bumblefoot.



Traumatic and ischemic lesion of feet: improper, narrow or thin jesses most commonly causing strangulation. If it is left unnoticed, it can result in extensory tendon rupture or whole toe amputation. In hawks a thin leather jess on the tarsal bone is especially stressing, biting birds can cause avulsion and aseptic inflammation of the first metatarsal bone. Local and systemic NSAID and long term rest with external cast fixation can lead to fibrotisation, but with permanent thickening of tarsal bone.

Bite wounds: by cats, foxes, squirrels are frequent hunting injuries. A tanic alcohol bandage quickly reduces swelling and in most cases prevents the need for blind antibiotics.

Frost bite of foot and wing tips: is frequent in warm climate species or in badly designed aviaries. Offering water baths in freezing day time or the skin in contact with metal parts of bells and rings can also be considered as a cause of these injuries.

Fractures: experienced veterinarians see many traumatic cases of falconry birds; listed here are a few typical fractures. The most common are transversal tibiotarsal bone fractures, especially in long legged species such as harris and goshawks, but also in Bonelli's and hawk eagles. These are frequently seen in young birds, especially hare and rabbit hunters as result of rotational twist. In golden eagle such a fracture occur while hunting roe deer. Falcons after hitting fences and natural barriers are presented with a variety wing bones fractures.

Electrocution: severe injuries if not actually lethal. Birds will demonstrate severe soft tissue damage especially in the wing tips and metacarpal region and on the exit point of the current, most often on the foot. Wing tip oedema manifests by loss of primary feathers.

Bumblefoot: the ischemic origin pododermatitis affecting large breeds of birds, heavy weight, lack of flying and hard perching are the cause of this typical disease of falconry birds. In all aspects of suggested treatment prevention is the best solution for long term management. Introducing double bar perches markedly reduced the frequency and severity of cases. After all recommended procedures to control the infection the latest progress in foot pad reconstruction are a vascularised pedical flap in combination with hydrocolloid absorbable dressing together with autolog PRP-platelet rich plasma treatment.

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Falcon Management Workshop

Dr. Ladislav Molnar PhD

Session was open to visiting vets, veterinary students, IAF Delegates and any falconer participating in the week's events. It included topics in basic management: food, mews, moulting etc. It covered advice on pre-purchase veterinary examination of falcons. The advice was aimed at falconers and to veterinary students and vets wishing specializes in falconry and who may not yet have sufficient experience

As falconers in different countries of the world implementing in their training techniques the same principles and routine procedures, like taming, feeding, housing, fitness training, game introduction. Avian veterinarians specializing in falconry birds treatment should standardize their examination and treatment protocols. This can speed up information exchange between veterinarians, standardize the communication and improve the veterinary care standards for falconers.

The aims of the workshop:

- to describe the widely used patient examination protocols in veterinary clinics.
- to identify the most common problems falconers facing from birds health problem site.
- to discuss the limitations of veterinary science related to novel disease
- to mark the most urgent points of interest and veterinary research related to falconry
- to give a platform for experience exchange.

Next to the 21st century standard protocols also there is the need to focus on training specialist in countries where technological or language barriers limit falconers' access to a good standard of veterinary services. Workshops should list the basic as well as advanced examination and treatment protocols. If we want to answer the question what are the main tasks of good falconry related veterinary service and good falcon health management, the basic statement is due to intensive breeding or national legislation birds of prey are widely available for falconers and their main questions to answer are:

1. How to select a healthy falcon for training - requirements for a good "pre-purchase "examination
2. If you have got a healthy falcon, how to keep him fit and prevent disease- requirements for good preventative program including husbandry welfare and routine examinations
3. What are the standards of health care in „loose falcon" management-veterinary measures in moulting and breeding chambers?

Participants comments, suggestions or experience on the above problems and topics were welcomed.

THE IMPORTANCE OF BREEDING HEALTHY FALCONS

Dr. Faris Al-Timimi Dr Al-Timimi , Veterinary Clinic, Katara, Doha, Qatar

The future of falconry could be entirely dependent on the future of captive breeding of falcons. For many decades, falconers in the Gulf region were obtaining their falcons from the wild. Captive bred falcons were brought to the Gulf countries for the first time in the mid to late 1960s when a falcon breeder from Canada and later on other European falcon breeders, from Germany in particular, brought their captive bred Gyr falcons to the Gulf. One of the well known old falcon breeders told me the story of his first time visit to Qatar with few of his elegant large size captive bred Gyr falcons. At the beginning, they were very much loved and appraised by the elite falconers, which did not take long until they were not satisfied by their falconry performance! Almost the same thing happened with other white captive bred gyrs which were brought from Germany on 1982. Unfortunately, the attempts of using those captive bred falcons for falconry were not successful at that time, and all of them failed to satisfy the ambition of the Gulf falconers in a very keen falcon, which is needed to challenge the demand of the Arab falconry, by chasing the difficult prey, the houbara. It was very clear that the failure of those falcons was because of the wrong way they were raised in their breeding pens, which was a problem obviously solved later on, by adopting other more suitable ways of raising baby falcon chicks until they are ready to fly. This tells us that we always need to improve our techniques as long as we want to have better results and productions.

In the old days almost all of trapped falcons carried different worms like Airsac worms (Serratospiculum), Trematodes, Capillaria and rarely Ascaris. Coccidiosis was not commonly detected in the examination of faecal samples of those recently arrived falcons. The reason of that was probably, because the falcon traders tended to feed the falcons in their possession either on mutton or beef, which are not so expensive, and do not need extra work to prepare as food for the falcons, especially when they have large number of falcons. Beef and mutton do not carry avian parasites. Captive bred falcons usually do not have a problem with worms unless they are really hacked for a considerably long period of time, when they start hunting for themselves and feed on wild birds or mammals. However, many exported captive bred falcons were showing either a mild or sometimes severe respiratory infection due to Aspergillosis, which could be detected soon after their arrival to the end customer. Many falcons could also have Hepatitis due to Herpes virus infections and Aspergillosis was also not uncommon in transported trapped wild falcons due to housing and transportation methods.

Cases of Aspergillosis due to Aspergillus fumigatus with secondary infections of other causative agents like, Proteus mirabilis, Klebsiella pneumoniae, Pseudomonas aeruginosa, have been recorded since the early years of 1980s when I started my work in Doha. I have briefly reported some of them with many images showing different degrees of infection in my first book “Falcons and Falconry in Qatar” published 1987. During the years of early 1980s, I was privately and out of my interest sending different specimens from the dead falcons to England to be examined pathologically by my friend Dr. John Cooper, and bacteriologically by another friend Jeffery Needham. There was no sponsor for those attempts of studies of those cases and specimens, which was why I did not carry them out for further studies due to the high cost of the tests and transport of specimens. The falconers here in Qatar were already familiar with these fatal and hopeless cases of (Ridad) which is the general term given by the falconers to every clinical case with respiratory nature. However, they were bringing them to me on the hope that something could be done with regard to finding the cause and then the appropriate treatment for this lethal disease.

It is becoming clear that the future of falconry in the Gulf region is going to be -sooner or later- dependent on captive bred falcons and therefore, it is very important to satisfy this need with the most suitable falcons, which should be up to the standard of requirement by Gulf Arab falconry requirements of a keen, healthy and a hardy falcon and by the harsh environment of the Gulf and its extreme high temperatures and humidity. Western Falcon breeders chose and worked hard to introduce the Gyr falcon to the Gulf Arab falconry. At the beginning, they started with the pure gyr, and then they went on with both, the pure as well as gyr/hybrid falcons. The gyr falcon turned out to be the most unsuitable species of falcons to be used for falconry in this area, but the breeders did an amazing job to make this falcon and its hybrids available to almost every Arab falconer. This was assisted by the natural tough features of this falcon which made it like a killing machine, but only covered with nice feathers. There is no doubt that captive bred falcons, gyrs in particular, are the least adapted falcons to the Gulf climate, which is why we do not usually see pure gyrs older than six or seven years old still living in the Gulf region. The Arab falconer usually needs the service of his falcon for not more than 4-5 years, unless it is a very good spotting falcon which is used to identify houbara from a long distance. Every year, we are facing a problem of high incidence of Air-sacculitis due to Aspergillosis and Hepatitis, which is mostly due to Herpes Virus. This high and increasing incidence of these two fatal diseases could be very problematic to the industry of captive breeding of falcons in the future and therefore, could bring a sudden and unexpected end to the honeymoon between Arab falconry and the captive bred falcons!

I am not sure how much we know about the natural immunity the gyr falcons have against the different causative agents of diseases out of the subarctic environment where they naturally live. However, it is not expected to be as high as the immunity of the other species of falcons, which naturally live and migrate over vast areas of Asia and North Africa, on those plains and desert which are hosting of falconry. Furthermore, we have to ask how much the falcon breeders are paying attention to whereabouts the captive bred falcons are

eventually going to spend their lives? Also, how well they can perform with respect to their general health when they are forced to live in a very harsh environment?

When we enhance the future of captive breeding of falcons and make it more promising to the practice of falconry and provide the optimum health protection to those captive bred falcons, we will be doing a great deal to help to protect wild falcons. This help is mostly dependent on falcon breeders worldwide improving the hygienic conditions in their breeding chambers. Also, to some extent it will need the help of the vets who are in charge of advisory to these captive breeding projects.

Updates in Treatment of Aspergillosis in Falcons

Dr Antonio Di Somma, Med Vet, From the Dubai Falcon Hospital, P.O. Box: 23919, Dubai, United Arab Emirates.

Abstract

A total of twenty falcons, including 6 gyrfalcons (*Falco rusticolus*), 10 gyrfalcon hybrids, 1 lanner (*F. biarmicus),* 1 saker (*F. cherrug*) and 2 peregrines *(F. peregrinus*), were admitted to Dubai Falcon Hospital for treatment of aspergillosis with voriconazole. Affected falcons showed general clinical signs including loss of weight, inappetance, dyspnea, inspiratory stridor, tachypnea and biliverdinuria. The diagnosis of aspergillosis was made from clinical signs, hematologic evaluation, radiographic features, endoscopic examination of the lower respiratory tract, cytological examinations of biopsy samples from air sacs and fungal cultures. Therapy consisted of oral administration of voriconazole by crop gavage twice a day for 3 days (loading dose) and then once a day for a further period of 18-87 days (Group 1) or twice a day for the entire period of 44-100 days (Group 2). Treatment with voriconazole resulted in successful clinical response, good survival rate and few side effects. Complete clinical resolution occurred in 70% (14 of 20) of the cases, a partial response was observed in 25% (5 of 20) cases and only 1 individual failed to respond to treatment (5% failure).

Introduction

Aspergillosis infections remain a significant cause of morbidity and mortality in animals and humans, despite advances in medicine and the emergence of new antifungal agents.Aspergillosis is a disease caused by infection with the genus *Aspergillus,* which is composed of approximately 600 species. Manifestations of the disease depend upon which organs are involved and whether infection is localized or disseminated. The principal agent most commonly associated with disease in humans and animals is *Aspergillus fumigatus,* an organism that grows rapidly on Sabouraud's dextrose and animal tissues with colonies having a diameter of 3-4 cm in 7 days.[5] The flat colonies are white at first and then bluish green as conidia begin to mature. In birds, aspergillosis is commonly caused by *A. fumigatus*, while isolation of *A. flavus* is less common and other species isolated include *A. niger, A. terreus, A. nidulans* and *A. glaucus.* Aspergillosis is a not transmissible disease and infections are acquired from environmental exposure.[6] Disturbances of soil or movement of hay or litter can produce aerosols that expose the respiratory tract to conidia.[7] Severely immunocompromised individuals are at risk of developing this opportunistic infection. Aspergillosis in birds is usually confined to the lower pulmonary system with florid lesions in the air sacs and in lungs. Less common manifestations relate to infections of the eye, brain, skin and joints.

Aspergillosis is the most commonly occurring disease among wild birds held in captivity and is an occasional problem in companion birds. Among the raptors, the species more susceptible to the disease are: Goshawk (*Accipiter gentiles*), Gyrfalcon (*Falco rusticolus*), Snowy owl (*Nyctea scandiaca*), Rough-legged hawk (*Buteo lagopus*), immature Red-tailed hawk *(Buteo jamaicensis*), Golden eagle (*Aquila chrysaetos*). Species considered more resistant include the Praire falcon *(Falco mexicanus*) and Harris hawk (*Parabuteo unicinctus*). The Bald eagle (*Haliaeetus leucocephalus*) is more susceptible in cases of lead poisoning.

In the Middle East, aspergillosis is the most important disease affecting falcons, especially during the training and hunting season. Predisposing factors include inadequate nutrition, poor ventilation of the rooms where the birds are housed, stress and adverse climatic situations, particularly in falcons originating from other geographic regions. The limitations of current therapies against aspergillosis include toleration problems and nephrotoxicity with amphotericin B and poor oral bioavailability with itraconazole. Voriconazole is a novel, wide-spectrum triazole antifungal agent with good activity *in vivo* and *in vitro* against A*spergillus* spp. Our study describes the diagnosis of aspergillosis and the efficacy of treatment with voriconazole in falcons presented with clinical disease.

Discussion

Treatment of aspergilllosis is often difficult because infections caused by *Aspergillus* species tend to become walled-off by the bird's inflammatory response, therefore the lesions are encapsulated and consequently isolated from the blood stream.[18] The prognosis is poorer if one must rely only on the systemic administration of antifungal agents. The best treatment is when the lesions are debrided and when topical therapy can be given in conjunction with early, aggressive systemic antifungal therapy.[18] Topical therapy may be achieved by nebulization and/or surgical air sac flushing.[18] As aspergillosis is often insidious in onset and slowly progressive, early diagnosis is important because clinical signs are often inapparent until fungal colonization is extensive.[18] The clinical signs are non-specific and dependant upon the organ systems that are involved. Avian aspergillosis is usually differentiated from other respiratory diseases by the granulomatous lesions observed at endoscopy and opacities in the air sacs at radiography. Typically a mild to severe leukocytosis is present and the differential count reveals a heterophilia with a left shift, monocytosis and lymphopenia. Definitive diagnosis is based on identification of the organism on cytologic examination of the lesions and by culture of the organism by the site of infection. *Aspergillus* spp are ubiquitous saprophytes, therefore diagnostic samples should be collected carefully using aseptic techniques.[5] Exudative fibrinous or purulent airsacculitis are also frequently seen in cases of mycoplasmosis, colibacillosis and chlamydophilosis. Mycobacteriosis and other mycoses should also be considered when granulomas predominate.[5]

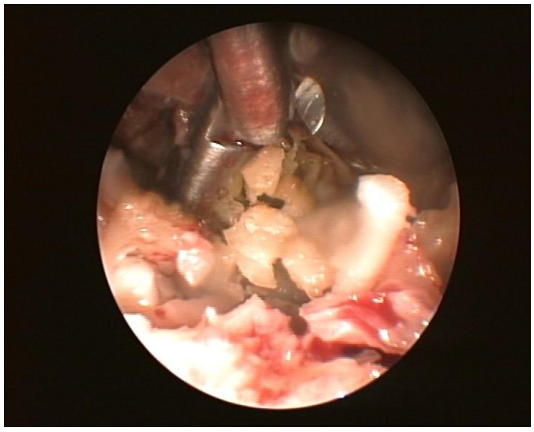
Traditionally, treatment for aspergillosis infections in birds includes the use of amphotericin B, itraconazole and terbinafine.[19,20] Voriconazole has some distinct benefits compared to the currently available antifungal agents.[21] It has reliable oral bioavailability and it has excellent activity against many *Aspergillus* spp that are resistant to currently available therapy.[22] Voriconazole was approved in 2002 for the treatment in humans for invasive aspergillosis, *Fusarium* and *Scedosporium* infections as well for the treatment of resistant candidiasis.[23,24] It is referred to as a second generation triazole. Structurally it has some resemblance to fluconazole but its activity is completely different. Voriconazole has some significant toxicities, but the majority of adverse events are similar to other triazole drugs and in particular are not life threatening[24]. In a recent study the MIC of voriconazole against *Aspergillus* strains isolated from falcons is consistent with those reported in human studies (Silvanose at al, in press). In this study 95% of fungal isolates, including *Aspergillus fumigatus*, *A. flavus, A. niger* and *A. terreus* were susceptible to voriconazole at MICs ≤ 0.38 µg/ml and 100% of the isolates at MICs < 1 µg /ml . In comparison in the same study, 21% of isolates including *A. fumigatus* (27.6%), *A. flavus* (16.6%)*, A. niger* (100%) and *A. terreus* (23%) were resistant (MIC ≥ 1 µg/ml) to ITZ.[25] Voriconazole in humans is has been approved by FDA for use in fungal infections where there is a probability of resistance to other available therapies or in patients who cannot tolerate other therapies. Schmidt et al recently demonstrated that a dosage of 12.5 mg voriconazole/kg given orally q12h provided plasma concentrations > 0.5 µg/ml for 14 days in falcons.[26]

Aspergillus is ubiquitous, and infections should be considered to occur secondarily to an immunosuppressive event.[5] Although there was no evidence of a primary disease that immunocompromised the birds, environmental factors may have caused physical stress that predisposed the birds to the systemic fungal infection. As voriconazole is metabolized by the liver, liver function tests should be evaluated at the start of and during the course of the therapy to evaluate hepatic damage.[23] High serum concentrations of AST and lactate dehydrogenase found during our study in falcons have been shown to occur with liver or muscle damage. However, changes observed in this study were most likely caused by muscle or tissue injury associated with repeated venepunctures.

The fitness level can determine the raptor ability to survive when released back in the wild after a period in captivity[27] and this is a special focus of the rehabilitation programs in Europe and Middle East.

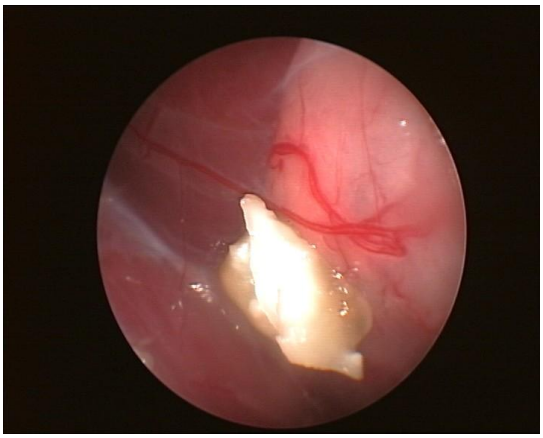
Conclusion

Our results demonstrate that therapy comprising oral administration of voriconazole by crop gavage twice a day for 3 days (loading dose) and then once a day (Group 1) or twice a day for the entire period (Group 2) provided adequate treatment for aspergillosis in falcons. This study suggests treatment protocols and voriconazole dosages in falcons based on the results in 20 birds housed in a strictly controlled environment. However, whether these protocols are applicable to other avian species remains to be determined.



Left: Collecting a biopsy of a granuloma for cytology and mycology to confirm a diagnosis of aspergillosis.

Right: Increased opacity, increased vascularisation and small plaques (<5 mm) on the caudal thoracic airsac of a falcon with early aspergillosis (Grade 1).



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RAPTOR SURGERY IN THE 21st CENTURY

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The word¨Surgery¨ has its origins in the Anglo-French word ‘‘surgien’’, from the Greek language ‘‘kheirourgi’’, from ‘‘kheirurgei’’ working or done by hand, from the two words ‘’kheir’’ hand and ‘‘ërgon’’ work. Raptor surgery has been performed since immemorial times but its evolution in the last 30 years, following some of the work done in small animal medicine, has been enormous. Nowadays many surgical procedures can be done safety and efficiently in our raptors. For any veterinary surgeon interested in falcon surgery should be very important to have previous knowledge about small animal surgeries, consulting books, talking with experienced colleagues, practicing with cadavers, take wet- labs at avian conferences, and have all the information they can gather. Also the literature is rich in birds of prey surgery examples but there are still many surgeries that should be investigated further and do not show on books or scientific papers.

Very important issues in raptor surgery are analgesia, anaesthesia and control of iatrogenic infections. Knowledge about respiratory, cardiovascular and metabolic pathways should be an important matter when working with raptors. For having a good outcome the majority of the surgeries should be accomplished with inhalatory anaesthesia (isofluorane) and a sound analgesia protocol. Most birds will be intubated, but on occasion, for short procedures, they will be maintained in anaesthesia by face mask. Monitoring of the slept bird could be done in many ways using traditional tools (phonendoscope, breathing frequency observation, corporal reflexes...) or more advance hardware like electrocardiography, doppler monitor, vital signs monitor, etc. In our experience combination of the above and the presence of an experience raptor anaesthetist during surgery should be a must for the good outcome of the procedure. In the author´s opinion a pre-surgical broad spectrum antibiotherapy and keeping short surgery times is the preferred method to avoid iatrogenic infections in falcons and keeping a low intrasurgical death rate. Use of broad spectrum antibiotics with lesser side effects is a good practice in raptor surgery. The reader should consult avian formularies for more information on this subject.

Pre-surgery. Before attempting a surgery on a bird of prey the surgeon should read the birds clinical history, perform examination at a distance (respiratory movements, body posture, eyes...), perform the effort test and clinical examination (at least should include full physical check and blood work, and other diagnostic probes as needed). Many times the bird should be treated for clinical and subclinical causes before the surgery (correct dehydration, antibiotic therapy...). For surgeries on the head and upper respiratory tract of birds of prey (enucleation, hyoid apparatus, trachea surgery) the surgeon should be familiar with intubation and air sac annulations anaesthesia techniques. The bird should be stabilized before undergoing any anaesthesia or surgery. Some raptors would benefit from fluid therapy, nutritional support, energetic support, hormonal support, or even blood transfusion, before lying on a surgery table.

As volatile anaesthesia is used in the majority of surgery cases control of hypo- or hyperthermia should be a must. Normal body temperature for birds of prey is approximately 41o Celsius and the thermic shock could be great if we o not take adequate measures for preventing it. For control of hypothermia the author uses electric heat pads under the bird. The pipe delivering the gas anaesthetic is passed under the heated pad so the birds receives warm air during surgery. Some species (Falco *rusticolus)* can suffer from hyperthermia in some climates, so no external heat should be provided.

Preoperative analgesia should be a must in every surgery on birds of prey. At our hospital we pre-medicate the bird with 0,3 mg per kilogram oral meloxicam half an hour before the anaesthesia and 1 mg per kilogram intramuscular butorfanol fifteen minutes in advance.

The surgical instruments and material used in raptor surgery should be accorded to the patient size and the surgeon should be confident with its use. Sometimes the use of microsurgery instrument is needed in some patients and some surgeries. The operating room should also contain a good cold light illumination (important for not drying the tissues during surgery), and magnification for smaller raptors. The use of radiofrequency apparatus proven in exotic animals is of importance when performing surgeries in birds of prey. In our hospital we rarely use a scalpel blade but the radiofrequency unit for most of the surgeries as blood loss can be a concern in some birds. The use of hemoclips should help the clinician to keep easier access and shorter surgery times. Also transparent surgical sheets help during surgery. When choosing a suture in raptors we use nylon for skin, polyglactin 910 for muscle and glyconate for gastrointestinal and reproductive tissues. Common sterility rules that apply to small animal surgery should be established when working with raptors.

A common rule for all raptor surgery should be adequate and soft management of tissues.

Raptors flying in falconry should be treated as highly specialized athletes. The main aim of surgery in this birds is to restore their body or metabolism to normal optimal function. One of the main problems the clinician faces with the client is the prognosis for the bird. For wild raptors admitted to a rehabilitation centre the restoration should be that needed for a self-dependent predator. If that could not be achieved other destinies other than liberation should be seek. In falconry birds the owners would be the ones to tell us what will be the destiny of their bird. That makes a lot of difference between wild and captive raptor management and surgery.

In this paper we will present common surgeries in raptors that are not enough described or not described in the literature.

Soft tissue surgery.

Local skin flaps. One of the commonest surgical procedures in captive raptors is the management of large superficial skin wounds. Avian skin is thin and is well attached to underlying skeletal structures over the head, extremities and sternum, and less attached over

the rest of the body. Most of the presentations in normal practice are more than 12 hours old so dry wound edges and bacterial necrosis should be present. The use of advancement, rotation or transposition local flaps give good results for restoring these defects. Normally full thickness skin flaps produces good healing success. When the skin flap is not possible the use of extracellular matrix or hydrocolloid bandages should be considered. Some authors have review the use of auto grafts in the wound management of raptors but the technique is not commonly applied in real practice.

Ingluviotomy. Crop injuries and infections (abscesses, trichomoniasis...) are frequent presentations in raptor practice. The crop in birds of prey is located to the right of the neck. Passing a lubricated plastic nutrition probe down the oesophagus will help the surgeon to identify the structures and defects in the crop. The crop tissue should be free from subcutaneous tissue using blunt dissection, the abscesses can be retired using the radiosurgery unit if blood lost is a concern, and crop edges should be clean of necrosis and weaken tissue with scissors. Crop tissue should be cleaned and rinsed with sterile saline. Suture of the crop is performed using glyconate suture material in a single interrupted horizontal mattress pattern. The overlying skin is closed with single interrupted nylon stitches. Feeding the bird with a ventriculus cannula is performed during the 2 post-surgery days. Small and frequent meals are offered from then until 10 days providing no casting material during that period to the bird. In some big birds of prey (eagles, vultures...) endoscopic access to the proventriculus or ventriculus is gained opening a small hole in the ventral section of the crop.

Caesarean section. In birds of prey the size of the egg is typically large related to their body and dystocia could occur during the breeding season. As climate, age, and nutrition status of the birds play a significant role in this presentation, medical manoeuvres and patient stabilization should be performed before attempting this surgery. In the most ventral egg dystocias, ovocentesis could be an alternative to surgery. Surgery could be decided as an alternative when others extractive methods have failed or because the value of the egg. Most fertile eggs extracted via caesarean section are viable but need a sound incubation technique. The electrofrequency unit could be used to excise the skin over the linea alba. Blunt and careful dissection of subcutaneous tissue is recommended. Incision of uterine tissues is performed with a scalpel blade softly over the egg. Normally the egg is attached to the uterus wall mucosa so blunt and soft dissection is important. To avoid bigger incisions the egg should be rotated to its small diameter before extracting it from inside the uterus. Uterus is sutured using glyconate suture of appropriate diameter in a single interrupted horizontal mattress pattern. Linea alba is sutured with a single interrupted pattern using polyglactin 910 and the same pattern is applied to the skin using nylon material.

Cloacopexy. In birds of prey many causes (dehydration, parasitism, bacterial cloacitis, enteritis, hormonal profiles...) can lead to tenesmus and subsequent cloacal prolapse. In some occasions the prolapse can be resolved without surgery placing mattress suture across the vent. In others necrosis of the intestinal mucosa leads the surgeon to perform the surgery. Identifying and removing of the necrotic tissue (commonly mucosa) with the radiofrequency unit should be followed by suturing the mucosa to the cloacal sphincter with glyconate in a simple interrupted pattern. Treatment of the underlying cause and offering a soft diet should be performed in order to prevent relapses.

Prepatagium wounds. In birds the prepatagium is the elastic fold of skin extending from the shoulder] to the carpal joint, making up the leading edge of the inner wing. This is a special and important tissue involved in raptors fly that frequently gets damage while hunting. Most of the times ventral and dorsal aspects of the prepatagium are damaged.

The aim of repairing surgery is to maintain flexibility of this wing web so care should be taken not to create fibrosis and ankilosis. If this happens the ability to fly will be handicapped. If the tear allows us to stitch it we should do so at the first instance. Dorsal skin and ventral skin should be stitched separately with simple interrupted nylon suture pattern. A figure of 8 bandage is applied for 3-4 days and physiotherapy under anaesthesia is done every 3 to 5 days.

Sometimes infections or delayed time to the clinic involves that greater areas of skin are necrotic and need debridement before repair. After the debridement the created hole is so big to get it stitched and the surgeon needs to apply hydrocolloid bandages, sometime sutured to dorsal or ventral side of the prepatagium. These bandages should be left in place for 5 to 6 days and changed with the bird under anaesthesia.

Trauma surgery

Hyoid apparatus surgery. The bones of the tongue collectively are called hyoid apparatus and allow extension and retraction movements of the tongue. Its functionality is essential to swallow the meat. In raptors the epibranchial horns of this bone attach to the parietal bone and muscles. These bones could be damage during fights with other raptors and lead to a bird that is unable to feed on itself as it cannot swallow the food. Many times delayed surgery is needed as a result of present infections and the bird should be maintained with force feeding. Surgery is performed in the damaged side opening the skin and getting access to the muscles and bones in the parietal area. Localization of epibranchial bones and its movement will reflect the actual detachment and the small depression where they were detached. The tip of the epibranchial is anchored the parietal muscles with 2 interrupted stitches using 5-0 or 6-0 non absorbable monofilament sutures . Proper tension and site placement of the stitches could be checked by normal tongue movements and position. The bird should be aided to swallow the food for another week. Then normal feeding is resumed.

Phalangeal bones surgery. Broken phalangeal bones is a common condition in broad winged raptors in Spain hunting small mammals (rabbits and hares). Sometimes conservative bandage techniques do not produce the desired effect and big osseous callus formation and deviation of the digit is obtained. In our hospital we are performing some techniques using cortical screws or threaded pins to fix and align the bone to get optimal results. Common trauma techniques and surgical approach are used in these surgeries.

Minimal invasive surgery Endoscopic surgery

Vasectomy. Due to hybrid falcon popularity nowadays this technique is normally performed in raptors to render the male sterile but with a normal sexual behaviour towards the female. In our country it is performed just before the breeding season (January) as a good development of the gonad will help in this surgery. A surgeon with endoscopy experience must attempt this procedure in a dead raptor first to adjust the values of the radiofrequency unit. The surgery could be accomplished with a 18 mm rigid endoscope equipped with an operating sheath with working channels, a 1 mm tip electrode, biopsy and grasp forceps and a radiofrequency unit. With the bird in lateral recumbency and the legs pulled caudally an endoscopic laparatomy to the abdominal sac is performed and the testicle and ductus deferens should be identified. The ductus deferens is encapsulated near the ureter and caudal renal vein by two fibrous coats. With the electrode these two coats are open in two places 0,5 cm apart over the ductus deferens. When this conduct is free from the fibrous coats it can be excised with the biopsy forceps. Once excised in both sides the free conduct is grasped with forceps and softly detached from its anatomy. The procedure is then performed in the contralateral side.

Air sac granulomas extraction. Falcons may suffer infections that can lead to granuloma formation inside their air sac system. Sometimes these granulomas can render a falcon useless to perform long sustained flights as they occupy an entire air sac thus producing respiratory alterations. With the aid of the endoscope and human grasping forceps these granulomas can be retired and normal function obtained. Incision should be kept to the minimum so anaesthesia can be maintained without awakening the bird unexpectedly.


Figure 1


Figure 2


Figure 3

CASE 1

Figure 1. Peregrine falcon with a head injury caused by other raptor.

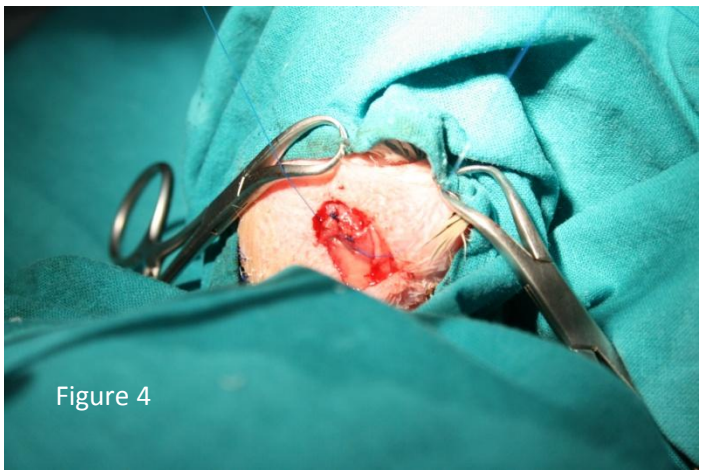
Figure 2. Creating the advanced flap.

Figure 3. Final closure of the skin in the peregrine falcon.

CASE 2

Figure 4. Sutures in the epibranchial of the hyoid apparatus in a hybrid falcon

Figure 5. Same hybrid after hyoid apparatus surgery



CASE 3

Fig 6. Female peregrine with egg retention

Fig. 7. X-Rays of the female peregrine falcon

CASE 3 (cont.)

Fig 8. Incision of the skin during Caesarean section

Fig 9. Egg extracted from the uterus

CASE 4

Fig. 10. Prepatagium injury in a black hybrid falcon

Fig. 11. Falcon hybrid after surgery with hydrocolloid bandage

Fig 12. The same falcon 15 days after surgery.

AN EMERGING WASTING SYNDROME IN PEREGRINE FALCONS*(Falco peregrinus)*

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ABSTRACT

Over the past 3 years approximately 30 adult peregrine and peregrine hybrid falcons from at least 3 separate collections as well as privately owned falconry birds in the UK have succumbed to an enteritis and 'wasting' syndrome apparently unresponsive to traditional treatment regimes. Based on the results of ongoing work our current working hypothesis is that this is a form of post infectious inflammatory bowel disease (IBD).

CLINICAL AND LABORATORY FINDINGS

Symptoms include general poor condition, weight loss (despite polyphagia), food begging vocalisations, mucoid diarrhoea, pale feet, cere and talons, polydipsia, regurgitation and in many cases progression to death despite culture-based antimicrobials and aggressive fluid/nutritional support. Although no single common food item or source has been identified most of the birds were fed mainly day old cockerels and/or quail.

Intensive ante- and post mortem investigations including faecal bacteriology and parasitology, electron microscopy, viral culture and high-throughput molecular techniques have failed to consistently identify any single virus, bacteria, yeast or parasite. A weak signal for Northern Aplomado adenovirus was obtained on microarray but further PCR testing using both avian and pan adenovirus primers failed to amplify a PCR product to support this finding.

Gross post mortem and histopathological changes mainly involved the intestinal tract, with histological evidence of segmental chronic lymphoplasmacytic enteritis (with variable numbers of heterophils), particularly in jejunum and ileum. Villi in these segments were wide and blunt (villous atrophy) in comparison with reported descriptions of normal[i], with occasional villous fusion. There was crypt hyperplasia. Although classically associated with viral infection, villus atrophy and crypt hyperplasia may be attributable to a wide variety of insults to the intestinal mucosa, including bacterial, protozoal and metazoan infections, food allergies/intolerances and drug reactions. Some cases remain idiopathic. No protozoa or viral inclusions were recognised in any case, but small to excessive numbers of intraluminal bacteria of mixed morphologies were present. In one case, membranoproliferative glomerulopathy with tubular protein loss was present in the kidneys, a lesion typically associated with the deposition of circulating immune complexes from persistent inflammatory stimuli.

In parallel, biopsies were taken from the small and large intestine from selected end-stage cases under terminal general anaesthesia. These were snap frozen or placed immediately into RNAlater. Snap frozen biopsies were fixed in formalin, wax embedded and examined by fluorescence *in situ* hybridisation to identify and localise bacterial infection. For biopsies in RNAlater, mRNA was extracted using a Promega kit. Levels of TGF beta, IFN gamma, IL-10, TNF alpha and IL-6 were analysed by qPCR using a Stratagene 1 step qRT-PCR kit with primers designed using available DNA sequences for *Falco* spp. from GenBank. Affected birds had large numbers of bacteria colonising the intestinal mucosa, most of which were considered to be intestinal commensals, although clostridia were often identified. Biopsies from affected birds showed higher levels of IFN gamma, TNF alpha and IL-6 than those from control birds (wildlife trauma cases euthanized on humane grounds). These are all proinflammatory cytokines, and this profile is consistent with that seen in human IBD. The marked difference was that in humans elevated TGF beta is also seen, an elevation absent in the affected birds. Elevated TGF beta causes excess collagen deposition in the submucosa in humans with IBD, and is responsible for thickening of the gut wall and the development of fibrosis[ii]. Histology showed that affected birds did not show fibrosis. In humans, IBD is a Th-1 disease, and the activity of these cytokines is co-regulated by the transcription factor T-bx21. Our analysis of avian genomes indicates that chickens do not have a homologue of this factor. It is likely that regulation occurs by a different mechanism that does not involve TGF beta or promote fibrosis. The clinical presentation of IBD in birds could therefore differ from that in mammals.

The picture suggests that an initial inciting infection compromises intestinal barrier function before resolution/clearance. Excessive numbers of commensal bacteria remain colonising the intestinal mucosa, promoting a feedback loop of inflammation, breakdown in epithelial barrier function, further bacterial colonisation and persistent inflammation, as described for chronic human IBD[iii]

CURRENT MANAGEMENT RECOMMENDATIONS

The authors recommend that falcons presenting with these clinical signs undergo complete physical examination with faecal analysis for the presence of intestinal parasites, protozoa or microbial pathogens, which should then be treated with appropriate culture-based therapeutics. Meloxicam, oral aqueous aloe vera and probiotic/competitive exclusion products e.g. Flightpath (Microbial Developments Ltd.) are useful adjunct therapies in such cases.

Affected birds may respond to dietary conversion to a novel protein, perhaps reflecting an underlying hypersensitivity to antigens breaching the intestinal mucosal barrier during an inflammatory episode. With polydipsia a common feature of this syndrome it is essential such birds have unlimited access to fresh water to avoid dehydration. In refractory cases, based on the hypothesis of IBD, a number of protocols including oral sulphasalazine, metronidazole, budesonide and intramuscular dexamethasone have been attempted with varying results. Although such therapies have proved useful in the management of acute 'flare ups', at the time of writing our clinical impression is that this may be a lifelong condition.

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RAPTOR NUTRITION:
What we feed them, what goes wrong , how we deal with it.

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KEYWORDS
Raptor – Nutrition – Hatchery waste - Day old chicks – Rodents as food – Pigeons as food – Adenovirus

ABSTRACT
The aim of this paper is to review the available scientific and practical falconry text on raptor nutrition in order that vets can advise falconers on feeding regimes, as far as possible based on proven scientific research, assisted by practical information.

INTRODUCTION
The argument, that in the absence of detailed nutritional data the dietary needs of any individual species are most likely to be met by feeding a diet closely approximating to that which would be taken in the wild under ideal conditions (Kirkwood 1981), can be contested. Firstly, without detailed nutritional data, how can 'ideal' conditions be identified? Even a relatively accurate analysis of 90% of a wild birds intake may not be truly reflective of the nutrient profile of the diet (Brue 1994). In the wild most raptors are opportunistic eaters i.e. they eat anything which is available e.g. feathered and furred quarry also insects, reptiles and carrion. Whilst some species have adapted over many thousands of years to a certain food intake, in many others the environment in which they live and hence the food availability will have altered, often at a rate faster than the birds' metabolism has been able to adapt (Brue 1994). A totally natural diet is impossible to replicate in captivity regimes (Dierenfeld et al. 1994), particularly because a wild bird has the option of choice (even if availability determines this), (indeed choice may vary with season and breeding activity), whilst a captive bird does not. In addition, captive birds may have different inherent nutritional requirements on account of their unnatural life style (Brue 1994). Wild birds often live short lives and death due to malnutrition is the most common cause of mortality in wild populations (Keymer et al. 1980; Hirons et al. 1979; Brue 1994). In essence, the modern falconer needs to develop feeding regimes based on the requirements of captive bred, raised and maintained birds as opposed to trying to replicate the, less than perfect, feeding patterns of wild raptors. Falconers bemoan the lack of scientific research into raptor nutrition for domesticated raptors. The primary reason to study nutrition, for the falconer, should be to improve the wellbeing of the raptors in our care. There are many factors that can influence both the quantity of food required by a raptor and its' requirements for specific vitamins. Life style, husbandry, geographical area, different stages of the life cycle, for example the stage of development, growth rate, health status and production level of our birds can all affect their nutritional requirements. Our aim should be to achieve / maintain optimal health: greater longevity (achieving the full potential [flight and breeding] life span of your raptor) may be possible by optimising the diet as some dietary components may have protective effects, for example, antioxidants are known to help reduce cholesterol levels. Promote disease avoidance: nutritionally related disease can occur, which with knowledge can usually be avoided, for example:

DIRECT, because of inappropriate diet content or quantity:
Starvation;
Malnutrition / sub optimal nutrition;
Metabolic Bone Disease (Ca:P:D3 in balance) (i.e. rickets);
Obesity (leading most commonly to cardiovascular or liver disease);
Toxicities (e.g. excessive fat soluble vitamin supplementation, or mineral poisoning);
Competition for food between birds in the same aviary.

INDIRECT, as a consequence of altered requirements due to other conditions:
Management techniques and housing;
Rapid levels of neonatal growth;
Fledging;
Moulting;
Reduced or ineffective plumage leading to increased heat loss;
Breeding, egg laying and rearing;
Old age;
Increased or decreased exercise;
Following medical treatment e.g. antibiotics altering the gut flora;
During recovery after illness or treatment;
Altered ambient temperatures;
During periods of high stress e.g.:
Adverse weather reaction;
Weight reduction prior to entering;
Injury, change of aviary / husbandry or other conditions leading to sudden increases in metabolic rate.

DISEASE, leading to:
Reduction in appetite;
Reduction in availability of food (e.g. parasitism);
Diarrhoea – decreased absorption of nutrients and electrolytes in view of increased transit rates;

Reduced ability to store or mobilise nutrients, especially in liver disease.

GENERAL ILL-HEALTH, for example:
Metabolic disorders, e.g. liver disease, thyroid disorders, diabetes;
Neoplasia (i.e. cancers);
Senility

FOOD QUALITY, for example:
Excessive storage times reducing nutritional value;
Excessive storage times reducing water content;
Restricted food source / type, leading to limiting factors e.g. essential amino acids;
Poor hygiene precautions resulting in bacterial contamination;
Reduced quality food e.g. rancidity (excessive storage) which reduces vitamin E levels;
Usage of incorrectly balanced food supplements;
Excessive or inappropriate usage of food supplements.

HOW ARE NUTRIENT REQUIREMENTS QUANTIFIED?

In establishing dietary requirements the goal is to determine what amount of food or particular nutrient is sufficient, if ingested routinely, to prevent impairment of health even if intake becomes inadequate for a short period, for the life stage and life style intended.

1. Maximum growth in the young

This is a common criterion used for commercial animals. However: whilst maximum growth is advantageous in birds destined for meat production, very rapid growth rates are often contra indicated in raptors (Forbes and Rees Davies 2000)

2. Maximum breeding production (to fledging)

This is also a common yardstick, although excessive production of you can harm the parents and result in poor quality off spring.

3. Prevention/cure of deficiency diseases

This depends on the observational endpoint chosen. (E.g., 5-10 mg of vitamin A per day prevents growth defects, but skin tissue becomes discoloured at this intake level). Seemingly this criterion could on occasion, therefore, be considered inappropriate in the light of the current concern for levels that promote optimal health as opposed to disease prevention.

4. Saturation of tissue

Determines the amount that will not cause any further increases in concentration of the nutrient in the tissues. Problem: some nutrients (e.g., fat-soluble vitamins) dissolve in adipose tissue, and will accumulate to toxic levels, leading to potentially life threatening diseases.

5. Balance studies

Method -- measure input and output; when they are equal, assume the body is saturated. Assumes that the size of the body pool of the nutrient is appropriate and is not changed by the experiment. Assumes that higher levels of intake would do no good (clearly not true of water -- hardly anyone would recommend just enough water to maintain balance). Such results are only relevant to the bird in that controlled environment, at that life stage.

6. Changes in a secondary variable

Changes in some secondary variable in response to the nutrient may be measured, e.g., changes in copulation frequency in tiercels in response to Vitamin E supplementation.

7. Amounts in typical diets

Sometimes it is difficult or impossible to determine the amount of a nutrient that is required. In such cases the amounts that seemingly healthy raptors in a wild population take in may be accepted as the norm. These levels, however, may be limited by population levels, prey availability, seasonal factors, lifestyle or geography (raptors in the wild may not need vitamin D in their diets, however, those kept in poorly designed, dark aviaries may).

WHAT IS AN ESSENTIAL NUTRIENT?

The classical definitions are:

Essential nutrient: substance that must be obtained from the diet because an animal cannot make it in sufficient quantities to meet its needs. Biotin is necessary in metabolism, but raptors normally produce sufficient quantities within their bodies. In contrast, pantothenic acid is equally necessary, but it is not produced internally. Hence, pantothenic acid is an essential nutrient.

1. Macronutrient: nutrient needed in large amounts (many grams daily).
2. Micronutrient: nutrient needed in small amounts (typically milligrams daily).

Conditional requirements: some substances are not generally considered essential to life, but might become so under specific circumstances (that is, conditional deficiencies are possible). The existence of conditional deficiency states may give rise to exaggerated claims of the importance of certain substances in normal diets, leading to the recommendation of unnecessary routine supplementation. For example the supplementation of a raptors diet with thiamine may be recommended for fish eating birds. These may improve in condition and cease fitting if the supplement is given. The additional thiamine, however, is only required, because of the naturally occurring ‘thiaminase’ (an enzyme which digests thiamine) in the fish, which is destroying the normally available levels of thiamine.

OUTLINING THE BASICS OF A FEEDING REGIME

As a basic principle, it is important to remember that each raptor species has evolved over millennia to fill a very specific ecological niche (Brue 1994). The consumption of a prey animal by a raptor involves the bird eating casting (fur & feather), muscle, bone, viscera and the prey's gut content. In supplying food to captive birds, all these elements should be considered. Any alteration to the birds diet, even from one prey species to another, in either captive or free living individuals can result in a change in the relative proportions of these materials consumed. It has been established that a raptors food requirement varies with body size. Buzzards, kites and eagles require approximately <10% wet weight, in food, of their body-mass per day, large falcons and Accipiter species 10-15%, whilst small falcons and accipiters 20-25% (Kirkwood 1980 & 1985). Total food requirement, therefore, can be seen as a correlation between an individual birds digestive efficiency and its metabolic rate.

COMMONLY USED RAPTOR FOOD

Day-old chicks: are often, mistakenly, considered to have the equivalent nutritional value of a single hen's egg. This is not the case. The formation of an embryo within an egg and the development and subsequent hatching of a chick dramatically changes the chemical and nutritional value of yolk and albumen (Table 3). Day-olds are used as the basis of a staple diet for the majority of species of birds of prey. Offering a high protein, low fat diet with good levels of vitamins and calcium. In a recent study, the body composition of young American kestrels (*Falco sparverius*) fed on a diet of either day-old cockerels or mice were compared. This comprehensive study (Lavigne et al. 1994a & 1994b) provides ample evidence as to the nutritional adequacy of day-old cockerels as a food source for American kestrels. It should of course always be remembered that not all chicks, mice etc. are equal, the nutrient value will in turn be governed by what they were fed on. The calcium levels, which are required by growing birds of prey, would be met by any of the whole prey outlined in Table 3 (Dierenfeld et al. 1994). Calcium levels, however, also need to be evaluated in relation to both dietary phosphorus (P) and vitamin D_3. Ca:P ratios of 1:1 – 2:1 have been reported for indeterminate egg layers (poultry) with determinate egg layers i.e. those birds which lay eggs during a specific breeding season e.g. raptors, requiring lower levels (Bird & Ho 1976; Dierenfeld et al. 1994). Day-old chicks have the correct Ca: P ratio (the most important single factor) as well as good overall levels of calcium. The conclusion, is that day-old chicks are the ideal staple diet for most species of birds of prey, being nutritionally sound, with high ME/GE ratios, as well as being economically priced, readily available and convenient to use. As previously discussed, however, it would be most unwise to feed exclusively one type of food, therefore, a varied diet is always indicated.

Quail: At 6-wks old there appear to be no nutritional differences between male and female quail, however, at 16-wks of age marked differences appear: the nutritional quality of males remains unchanged yet the fat levels in female quail have almost doubled (Clum et al. '97).
Age and sex differences in quail leads us to classify the main types that are available as follows:
5 week old male culls, 6 – 8 week old prime birds, 8 month old ex-layer birds, Vitamin E enhanced quail. Quail become sexually mature at 6 weeks of age, therefore, the most readily available quail are surplus males that are culled at 5 weeks old, i.e. those birds not required for breeding programmes. 6 – 8 week old birds are generally considered to be the best quail readily available and are suitable for most raptors. 8 month old layer birds are the by-product of egg production, frequently yolk and fat filled and often carrying significant levels of pathogens and disease. These birds can represent a bio-security risk to captive raptors. Vitamin E enhancement of quail fed to falcons, at the Peregrine Fund facility Boise Idaho has seen:
Improved libido effects in adults (increased copulation frequency);
Increased hatchability of eggs (59% to 83%);
Increased activity in chicks with, for example, food begging occurring between 4 & 10 hours earlier than in previous years (although one accepts this was not a controlled trial). It should be remembered that in the same way as our birds are as good as what we feed them, so in turn the food we feed our birds is only as good as what they, in turn, were fed.

Rats: notwithstanding the above comments regarding vitamin E enhanced quail, rats are naturally high in vitamin E, therefore, a strong argument exists for using both rat and quail as part of a feeding regime. Rats appear to be almost opposite to the quail in that the younger the rat the higher the vitamin content (Dierenfeld 1994).

Hamsters: nutritionally equivalent to rats, hamsters may be a good substitute for those falconers who do not wish to prepare rats. The thin skin and fur combined with their smaller size, means that hamsters do not require evisceration and can be fed whole.

Guinea pigs: are herbivores and so have long digestive tracts and require evisceration prior to feeding. Guinea pigs have very loose fur, which can quickly fill a falcon's crop and should be totally skinned before feeding.

Mice: are typically the most expensive food available to smaller hawks and owls in terms of their cost to weight ratio. Clum et al. 1997 expressed concern over their particularly high levels of vitamin A. Additionally, their high fat content and low protein levels (Lavigne et al. 1994a & 1994b) suggests they are less suited to feeding to birds of prey than appreciated.

Wild prey species: any wild source of food (e.g. pigeon, game, road traffic kills) must be considered potentially contaminated. That animal failed the 'fitness for life test' and we do not know why. Such birds may be carrying pathogens, parasites or toxins. Many falconers' feed ferreted, rifled or shotgun shot foods (especially rabbit and pigeon). Shotgun killed quarry should never be fed. Rifle bullets frequently fragment on impact, so even head rifle shot food should be discarded. Ferreted or hawk caught rabbits may contain lead pellets from a previous non-fatal shooting incident. Lead ingestion from the consumption of fallen shooters quarry is a major cause of mortality especially in free living eagles (Saito et al., 2000). Keepers should be aware of the clinical signs of lead poisoning (weakness of legs and wings, inability to stand, often grasping the feet each in the other, inco-ordination, poor appetite, green faeces, and weight loss). It only takes one lead pellet to kill a raptor; any suggestive signs should result in immediate presentation to an avian vet for examination and appropriate life saving therapy.

Other foods: the feeding of muscle (e.g. shin of beef) as a major part of the diet is unsatisfactory without supplementation. Birds flying on public display, are often fed beef as the public may object to seeing fluffy chicks or mice fed. This can lead to calcium deficiency even in adult birds presenting with central nervous signs or muscle cramps. Dietary composition is more critical in neonates than that of adults. The diet for chicks and growing eyasses must comprise whole carcasses, and not simply muscle (i.e. meat). When considering eyass diet it is important to study the food that is being consumed by the chick, rather than the food which is being offered to the parents, the two may be very different.

In conclusion, no one raptor diet can be ideal for all species. Day old chicks may make up the mainstay of raptor diets, but should be supplemented with variety of other wholesome foods, this is the case for both hunting and breeding birds. Falconers should not neglect the vitamin and other trace element requirements of their birds when limiting food intake in order to control weight for flight training.

PROBLEM AREAS TO BE AVOIDED IN FEEDING

1. Ignoring differences between species

There may be a temptation to feed the same feeding regime for all birds of prey. The nutritional requirements of hawks, falcons, eagles, owls, secretary birds or ospreys, vary between genera, with age, reproductive cycle and whether the bird is being flown, moulted out or free lofted. Wide variances exist between species, for example, European Kestrels (Fal*co tinnunculus*) can breed successfully for several generations on an exclusive day old chick diet (Forbes & Cooper 1993). In contrast merlins (*Falco columbarius*) fed on the same diet will not thrive. Free living merlins consume a predominantly insect-based diet and a high fat diet may be a contributory factor in Fatty Liver Kidney Syndrome of Merlins (Forbes & Cooper 1993). The diet of free living Secretary birds (*Sagittarius serpentarius*) is predominantly snakes, which are lower in energy and higher in Ca:P ratio than most commercial raptor diets. Young fast growing Secretary birds fed on standard raptor diets may suffer a Ca:P:D_3 in balance with resultant metabolic bone disease (rickets).

2. Unnecessary or excessive vitamin supplementation

Vitamin supplementation is not a good substitute for good basic nutrition (Sandfort et al. 1991, Forbes & Rees Davies 2000). Furthermore, if raptors are being fed a good diet, supplements will only be required at times of additional stress (e.g. training, moulting, breeding), if at all (Forbes & Rees Davies 2000).

The problem is two-fold:

a. Incorrectly balanced supplements, for raptors i.e. a vitamin/mineral supplement based on the nutritional requirements of one species is unlikely to be suitable for another (Angel & Plasse 1997, Forbes & Rees Davies 2000). All fat-soluble vitamins compete with each other for absorption. Hence if any one of the fat-soluble vitamins is available in excess there can be competitive exclusion in the fat micelle. This leads to an antagonistic interaction among the vitamins. A vitamin supplement formulated for one species may well be incorrect for another. Any supplement used should be one prepared professionally specifically for raptors.

b. Inaccurate supplementation, either in an attempt to 'do good' i.e. in the mistaken idea that if one pinch is good, two pinches are better, or simply through lack of accurate manufacturers guidelines. In a study undertaken at Houston Zoo (Angel & Plasse 1997), wide variations were found amongst individual keepers' interpretation of the quantities of supplements that should be added to avian diets. "A pinch" was found to weigh between 0.1 and 1.9 g. Vitamin supplementation added directly to the food has also not shown any detectable differences in health although food supplementation when provided in the food to prey species, has shown benefits to the secondary consumer (Dierenfeld et al. 1989).

In conclusion, varied, whole animal diets are desirable as they require little or no supplementation (Carpenter et al. 1987, Burnham et al. 1987, Dierenfeld et al. 1994, Bruning et al. 1980, Lavigne et al. 1994a & 1994b, Forbes and Rees Davies 2000).

3. Monotypic diets – (being provided with only of one kind of food)

Despite the adequacy of day-old cockerels as a staple food for many species of raptors, monotypic diets are unlikely to be advisable. Manganese deficiency, for example, has been documented in captive raptors fed a diet containing exclusively rat (Clum et al. 1997).

4. Monophagism – (habitual eating of only one kind of food)

Comparative work on digestive efficiency of birds of prey has shown that the Common Buzzard (*Buteo buteo*), a generalist species, has a greater digestive efficiency on a wider range of prey than the Peregrine Falcon (*Falco peregrinus*), a specialist species (Barton & Houston 1993). Such variation in the ability of different species to extract nutrients from their food requires the falconer to consider the dietary suitability for his own species and to ensure that the birds of prey in his care do not become locked into eating a narrow selection of foods. Raptors have no innate nutritional knowledge. Like children who would eat burgers and sweets daily if allowed, raptors may be selective. Only enough food of a single type per day should be fed, with diet variation taking place over a period of time, in order to ensure that large enough portions of each food type are eaten thereby maximising the nutritional advantages of each food consumed.

5. Excessive food provision

Birds eat to satisfy energy demands, so on a diet high in energy e.g. a high fat diet; they will eat less and therefore may not obtain the required micronutrients or trace elements from the food they consume. Although the dietary requirements of a captive raptor are less than that of a wild bird, their micro nutrient and trace element requirements will be the same, i.e. proportionately they require more trace elements. Whilst food energy content control is strict in flying birds (for weight control), it is less certain in aviary birds, such that obesity can arise. Excessive feeding leads to selectivity, potentially deficiencies, obesity and the potential for food decay, ingestion of spoiled food and the attraction of vermin.

6. Incomplete diets

Whole diets comprising flesh, bone, skin and casting materials are preferable to partial diets comprising just lean meat. Bones, for example, found in pellets cast by the gyrfalcon, (*Falco rusticolus*), were heavily modified by digestion, with traces of digestion observed on more than 80% of articular ends, nearly 100% of broken surfaces and on some shafts. It would appear, therefore, that the digestive tract of falcons are adapted to cope with bone structure and that the high levels of digestion found suggest that bones form an important part of the diet of birds of prey.

5. Over enthusiastic evisceration

The liver of an animal stores over 90% of the vitamin A content of a carcass as well as many other vitamins (Annex B). The evisceration of animals, therefore, beyond the removal of the intestines (where necessary) should be avoided. The routine de-yolking of day-old chicks will also dramatically reduce their vitamin A content and is not recommended except in specific situations, for example when feeding merlins, when yolk once a week is the maximum recommended frequency (Forbes and Cooper 1993)

7. Poor preparation, storage and handling

The manner and duration of storage can dramatically affect food quality and nutrient levels. Blast feeding of day-old chicks, for example, produces a significantly higher nutritional quality end product when compared to slow freezing in a domestic chest freezer. If meat products remain at room or body temperature for any period during the euthanasia, freezing, storing, transport, storage, thawing, feeding process, bacterial levels which are bound to be present will be permitted to multiple – rapidly creating a dangerously contaminated diet. Food kept for protracted periods (>3m) in domestic and commercial freezers deteriorates in nutritional quality, particularly in terms of water-soluble vitamins and vitamin E. Freezing is a drying process and long-term storage (unless sealed) can reduce the water content of food. As birds of prey obtain the majority of their water intake from their food, moisture depletion caused by long-term storage can cause potential problems during warm weather. Food should always be sourced from reputable suppliers with modern large-scale freezing plant and with sufficient turnover of stock to ensure that the food supplied has been frozen immediately after culling and is supplied as soon afterwards as possible. The temptation of bulk buying to obtain quantity discounts, with subsequent long-term storage in domestic freezers should be avoided. The method of killing should be ascertained and it should be certain that no toxic or noxious substances could be in the food. Barbiturate poisoning has occurred in both wild and captive raptors after birds have been fed the carcasses of animals euthanized with pentobarbitone. Other possible toxic contaminants include alphachloralose, mercury, mevinphos and other pesticides. Animals or birds fed to raptors must not have been on any form of medication, or medicated withdrawn food prior to their death. The feeding of day old poults hatched from antibiotic treated turkey eggs has led to infertility (Forbes & Rees Davies 2000). The potential risks of zoonotic (diseases transferable to man from animals) infections should always be considered when handling raptors or their food.

VETERINARY ASPECT OF RAPTOR NUTRITION

Common deficiencies and excesses

Although this is already covered, since this subject is so important the practical aspects of Ca:P:vitamin D_3 are also considered, in greater depth, here. Ca:P:D3 in balance, metabolic bone disease (MBD), also commonly known as rickets is the most important nutritional deficiency of raptors. Birds may present with signs ranging from slight bowing of the legs, longitudinal rotation of the tibio tarsae to major multiple folding fractures of the skeleton and even fits. MBD is most likely to occur in fast growing larger species. Breeders should be advised not to feed such species ad libitum, but rather to restrain the potential growth rate. 'Angel wing' or 'slipped wing' (an outward rotation of the section of the wing from which the primary feathers originate) has been experienced in several fast growing larger raptors, in particular when being imprinted. This is readily controlled if diagnosed early by bandaging the primaries against the body, together with Ca, vitamin D_3 supplementation and restriction of the growth rate. The diet must comprise of whole carcasses, i.e. not simply muscle (i.e. meat). The author has investigated calcium deficiencies in free living Golden eagle (*Aquila chrysaetos*) and European buzzard (*Buteo buteo*). In the former case the young were parent reared in an area with limited ground game (rabbit or hare). The birds were feeding predominantly on fallen sheep and deer carcasses. However, the young were only consuming meat from the carcasses (as sheep and deer bones were too large for young to ingest). The buzzards were rearing young in an area with a significant rabbit die off due to myxomatosis. Food was plentiful and rabbit bones were too large for young buzzard chicks, moreover in view of excessive food availability selectivity of ingestion was encouraged. A similar situation can arise when a breeder feeds a whole carcass diet of rabbit and pigeon for the parent rearing say, young Harris' hawks (*Parabuteo unicintus*). Either the young are unable to consume the larger bones or the parents feed what is easiest. The result is severe MBD. It is always a question of what food is consumed by the birds rather than what is provided. Calcium deficiency may also be encountered in neonates produced by a hen with significant renal pathology, or from one which has laid an excessive number of eggs (due to egg pulling or multiple clutching). Any hen likely to 'multiple clutch' should be supplemented with Ca, D_3 as soon as the first clutch is completed. Calcium deficiency due to inadequate D_3 levels is less common in raptors in comparison with psittacines as most captive raptors have access to day light, this could change in the event of enforced housing due to avian influenza risk.

Obstructions

Casting: is the indigestible parts of the carcass, normally consumed and then regurgitated as a pellet by raptor. This includes hair, feathers and in some cases (e.g. owls) skeletal elements. Casting should not be given to any chicks under 12 days of age, and for some species (e.g. Merlin) not until 20 days of age. This applies in particular to 'hard' casting such as rodent fur, whilst chick down is considerably easier to deal with. Young chicks are typically unable to cast such material; leading to a proventricular obstruction and death. Clinically a firm swelling may be palpable caudal to the edge of the sternum. Standard medical treatment using prokinetics, oral and parenteral fluid therapy, and oral liquid paraffin is typically ineffective. Surgery of such debilitated neonates typically results in the chicks death. If instead the chick is force fed for a few days, so it increases in size, it will then typically be able to pass the casting itself. Breeding females with developing ovarian follicles and a swollen active oviduct may have difficulties with excessive casting due to lack of coeliomic space. Casting should be reduced rather than increased in pre-egg laying females. A normal raptor will produce a casting 8 – 16 hours after a meal. Birds cannot be fed again until they have cast. If feeding occurs prior to casting, a small intestine obstruction can arise. If presented with a thin or a weak bird, where it is desirable to increase the birds condition (weight), then frequent, small, cast free meals of readily digestible food (e.g. skinned day old chicks), should be given. As soon as the crop is empty the bird may be fed again.

Inadvertent ingestion of indigestible matter: On occasions organic material may be consumed with food (e.g. peat or vegetable material from nest ledges, wood shavings, which the bird is unable to cast. In such cases an ingluviolith or proventricular impaction may occur. Harris' hawks are considered the most intelligent of the common captive raptor species. They will at times 'play' with materials in their surroundings and can ingest various foreign bodies. One example is that they can learn to untie the knot tethering their leash to the perch. The leash can be pulled free of the swivel and the bird can then swallow the leash necessitating an ingluviotomy, although the bird will often cast it back itself. Large foreign bodies may be safely left 24 hours, in the expectation that the bird will naturally cast them. Owls, both in captivity and in the wild, occasionally eat very long twigs (on occasions 6 - 8 inches long). The bird may appear in appetent, uncomfortable and miserable. Sometimes the twig is 'cast', but on other occasions, it may perforate the crop or proventriculus with a grave prognosis. Endoscopic or surgical removal may be necessary. Another form of obstruction seen especially in the larger owls is the ingestion of pea gravel. The bird is presented with a history of having a good weight but marked loss of body condition. Gastric distension by the gravel reduces the bird's appetite and little or no food is ingested. The condition is often advanced by the time of presentation.

Ingestion of oversize food items: the feeding of rabbit or hare carcasses with intact femurs can cause problems. The bone may pass directly into the proventriculus and be digested. However, in larger raptors the bone may rotate into a transverse position in the crop or proventriculus. The bone may form an obstruction in the crop or perforate the gut leading to a terminal peritonitis. If the bone is broken (preferably without sharp ends) before feeding the problem does not arise. A similar situation can develop when pheasant or chicken necks are fed whole. The neck usually passes down straight, but occasionally will double over in the crop or distal oesophagus becoming. On occasions, birds will eat uncommon prey items. The most unusual obstruction encountered by the author was when a female red tailed hawk (*Buteo jamaicensis*) which had caught and eaten a hedgehog (*Erinaceous europaeus*). Initially the bird was fine, but after 18 hours with no casting, she was presented for examination. Barium contrast radiography confirmed the presence of multiple spines and fur lodged in the proventriculus. The obstruction was successfully removed via abdominal surgery.

Decreased motility: 'Sour Crop' is a common and often rapidly fatal crop stasis. Ingested meat is held within the crop being maintained at 38 - 40^{o}C, with no gastric acid or enzymes present to prevent bacterial multiplication. This occurs most commonly in thin or sick birds which are given an excessive crop of food. The most urgent action required is to empty the crop, which will generally require veterinary intervention. The most rapid and atraumatic method is, with the bird anaesthetised and intubated crop, ingluviotomy is performed, the crop lavaged with warm and closed immediately or a day or two later.

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AVIAN OPHTHALMOLOGY PRINCIPLES AND APPLICATION

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Summary
Certain avian specific capacities – like flying – are closely bound to fully functional vision underlining the importance of avian ophthalmology. In addition, ocular lesions in birds are an expression of systemic disorders more than in mammals and therefore represent an important diagnostic criterion. The ocular symptomatology frequently enables specific conclusions to be drawn on suspected disorders or it may even be pathognomonic for a certain disease. Thus, the avian eye may be seen – in a much larger extent than in mammals - as a „diagnostic window“. On an average, more than 30 % of all traumatised birds (incidence higher in raptors than in pet birds) are suffering from ocular lesions, which are most often hidden within the inner structures of the eye with haemorrhages arising from the pectin oculi. Ophthalmoscopy, i. e. examination of the posterior eye segment, therefore is obligatory in traumatised birds. Regarding these facts avian ophthalmology is not a highly specific working field within avian medicine but it should be an integral part of the general examination procedure. After a short review on anatomical and physiological peculiarities, commonly and newly developed routine ophthalmological examination procedures will be described followed by a description of clinical pictures in the eye of various patient groups based on an etiological schematization. It has to be pointed out, that avian ophthalmology is getting more and more important in terms of avian visual perception, which strikingly differs from that of man (including avian visual perception within the UV and the ability to resolve high frequency flicker rates). These aspects will be of great importance for animal welfare issues due to the fact, that commercial kept poultry is commonly kept under artificial light sources, which meet human visual perception requirements only but lack those of avian vision.

Introduction
In many birds the eye is the most important sensory organ. The capacities of the avian eye which exceed those of the mammalian eye in part are an adaptation to the specific way of life and habitats as well as physical activities that are closely bound to perfectly functioning vision (e.g. flying). Even partial impairment of vision that can be caused by any one of many known eye diseases, always has far-reaching consequences because compensation by other senses (including olfactory and acoustic sensory perceptions) is usually insufficient, if possible at all. Hence ornitho-ophthalmology occupies an important position in avian medicine (1, 2, 3, 4, 5, 14, 16, 17).

In bird medicine it still seems to be quite uncommon to examine the eye as a routine part of the physical examination. This contrasts starkly with the generally acknowledged fact that, among the representatives of the class of Aves, ocular lesions may be a particularly strong expression of systemic disorders - to a much larger extent than, for instance, in mammals. Therefore, the objective of the following paper is to present a synopsis of the routine ophthalmological examination procedure and important systemic disorders in bird patients that are either pathognomonic for certain disorders or, when considered in conjunction with other organic diseases, enable a specific diagnosis to be arrived at.

Significance of visual capacities
Visual function in birds is i. a. essential for flying, surviving in the wild and reproduction. The eye as the main sense organ in birds and its visual capacities have no general superiority compared to mammals but shows a highly specialisation as an adaption to living conditions. Thus visual acuity is 2 to 8 times higher compared to mammals, visual fields are up to 360°, stereo sis ranges from 0° to 70 °, maximum spatial frequency (the ability to dissolve a certain movement into single frames) is up to 160 frames/sec (10 – 15 in man) and minimum detection of movements is up to 15 °/hour (very slow movements). It should be recognized that ultraviolet-perception (UV-perception between 320 and 680 nm), an ability common in diurnal birds bound to special UV-sensitive rods within the retina and an aspect that has not been investigated very well to date, plays a probably plays a very important role in inter- and intraspecific communication based on plumage-UV-reflection, even in birds which appear monomorphic for the human eye, for the identification/assessment of fruit ripeness based on varying UV-reflection of fruit wax layers, for phenomena of

camouflage, orientation other. On the other hand even complete blindness is not a reason for euthanasia in pet birds. Thus, canaries, suffering from blindness due to cataract formation - a condition which occurs quite often in this species - act normal, as long birds the interior of the cage or aviary is not modified.

Anatomical peculiarities

Though there exist numerous anatomical and physiological differences - like the striated rather than smooth intraocular musculature, the anangiotic fundus oculi, the pecten oculi - basically the approach to avian ophthalmology is quite similar to that employed in mammalian ophthalmology. Some anatomical peculiarities with relevance for the ophthalmologist are:

Size and weight of the avian eye

- Axial length 8 mm (Kiwi, Aptery sp.) up to 50 mm (Ostrich, Struthio camelus)
- Weight (Oulus sinister (OS) and oculus dexter (OD) in man 1 %, Fowl 7 % (adult) resp. 12 % (juv.) compared to overall head weight

Weight

- Determination by anulus ossicularis sclerae (10 – 10 single bony platelets)
- Flat type (diurnal birds with narrow heads, for example columbiformes)
- Conical type (diurnal birds with broad heads, for example falconiformes)
- Tubular type (nocturnal birds, for example strigiformes)

Adnexal structures

Eyelids

- Palpebra inferior larger than palpebra superior (exclusive owls)
- Lower eyelid with „tarsus“, no meibomian glands
- Membrana nictitans highly motile, regulation of praecorneal tear film, protective function for cornea, „snorkel mask effect“ (compensation for loss of refractive power during underwater vision)

Lachrymal glands

- Small or absent glandulae lacrimaliae
- Large glandula lacrimalis membranae nictitantis (vel. Harderian gland)
- Replacement by nasal salt gland (aquatic species)

No musculus retractor bulbi

Complete decussation of chiasma opticus (no consensual pupillary reflex)

Anterior eye segment

- Striated intraocular musculature (highly motile iris corresponding to external stimuli, no sensitivity to parasympatholytics/sympathomimetics, no reliable pupillary reflex corresponding to light stimuli)
- Fundus diameter much larger than pupil diameter
- Ligamentum pectinatum/ciliary cleft with species specific peculiarities
- Lens with anulus pulvinus („Ringwulst“), accommodation range 2 (owls) up to 80 (waterfowl) D

Posterior eye segment

- Avascular (anangiotic) retina
- Afoveate, uni- or bifoveate retina
- Rods and cones (inclusive special UV-cones) in functional units
- UV-sensitive cones in most diurnal birds
- Slight retinal pigmentation in nocturnal, heavily pigmented retina in diurnal birds
- No retinal tapetum lucidum
- Pecten oculi

- Chorioidal, heavily pigmented structure
- Protruding into the vitreous
- Obscuring papilla nervi optici
- Pleated, vaned and conical type
- 32 functional theories: nutritive, thermo- and pressoregulative function most obviously

Ophthalmological equipment and examination procedure

Minimum requirement for basic and general purposes

- Focussed light source with magnification lens ("Finoff transilluminator")
- Instrumentation for manipulation of the eye lids (Graefe hook)
- Lachrymal cannula (Anel)
- Topical anaesthetics: Proxametacain, Oxybuprocain (duration of action approx. 7 – 8 min.) or Lidocain (duration of action approx. 17 minutes)

Advanced Equipment

- Slit lamp (magnification x 5 – x 15, better x 20)
- Monocular direct ophthalmoscope with 15 D lens or even better
- Head band ophthalmoscope with 30 and 78 D lens (additional aspherical 40, 60, 90 D)

General examination procedure - Adnexal structures and anterior eye segment

- Without restraint
  - Assessment of visus via food intake, reluctance to fly, orientation
- With restraint
  - Examination of the ear opening
  - Pupillary reflex
  - Examination of the anterior eye chamber with lateral illumination
  - Examination of the anterior eye chamber with lateral transillumination
  - Examination of the anterior eye chamber with retroillumination

Equipment and procedure for specific examinations

- Slit lamp biomicrography
- Gonioscopy (Lovac lens), examination of the angulus iridocornealis with the pectinate ligamentum. Aetiological assessment of primary/secondary glaucoma status.
- Tonometry. Estimation of the intraocular pressure (IOP). Use electronic short time acting tonometer or Schioetz – Tonometer in raptors. Standard reference values measured with an electronic tonometer calibrated for avian eyes, range from 9 to 22 mg Hg and are available for 42 species from 7 orders. Standard reference values for psittacines range from 12 – 15 mm Hg for nocturnal birds from 9 – 12 mm Hg, for various poultry species intraocular IOP values are as high as 22 mm Hg. Minimum corneal diameter for reliable value is 9 mm. Reference values for newly developed tonometers (Tonovet^{R} and Tonolab^{R}) will be available soon.
- Schirmer-Tear-Test. Test for the estimation of the lacrimal function. Use standardised filter strips of 2, 3 and 5 mm width. Standard reference values using filter strips of various width for 42 species from 7 orders showing a wide range of interspecific variations are available. Strigiformes show conspicuously low values.
- Electroretinography. Measurement of retinal function by recording electrical potentials after light stimulation. This technique gives no information about the visus, only on retinal function. Basic principles of electroretinography for routine examination have been established. Indications are retinal disorders and diotric apparatus opacities.
- Laboratory examinations include bacteriological examination of the conjunctival flora. Physiological bacterial flora contains gram positive bacteria, while gram negative bacteria are an indicator for pathological conditions. Standard reference values have been worked out for 42 different bird species from 8 orders.

Mydriasis and air sac perfusion technique

Induction of mydriasis is indispensable for the examination of the posterior eye segment (ophthalmoscopy). A major difference between the mammalian and the avian eye however is that the commonly used mydriatics of atropine and tropicamide have little effect in the avian patient due to a striated rather than smooth intraocular musculature. Therefore the iris is partly under voluntary control. It is essential to have a dilated pupil (mydriasis) to perform an ophthalmoscopy, i. e. examination of the posterior eye segment including the vitreous, the fundus and the pecten oculi. Therefore neuromuscular blocking agents such as d-Tubocurarine (3%; 0,01 - 0,03 ml; 1) may be used. As the drug penetrates the cornea insufficiently it has to be administered directly into the anterior chamber by paracentesis using a 27 - 30 gauge needle. This technique includes substantial risk for injuries of intraocular structures causing i. a. hyphaema, increasing intraocular pressure (IOP), transmission of conjunctival flora with consecutive uveitis and systemic side effects if larger doses than recommended are used. Therefore it is recommended to use this technique just for therapeutical reasons (prevention of posterior of anterior synechia resulting from uveitis and consecutive miosis).

An alternative for routine induction of a mydriasis as well as for intraocular surgery and surgery in the head area is the air sac perfusion anaesthesia. In principle APA consists of a retrograde perfusion of the lung-airsac-system through a perfusion catheter via the left caudal thoracic airsac. As a carrier gas 0,3 l/min/kg BW of O_2 is used. Effect of nitrous oxide application are a low potentiation of isoflurane of approx. 11 % and thus improvement of the circulatory situation and release of the surgeon from isoflurane waste gases. Higher perfusion rates than recommended result in respiratory alcalosis due to a CO_2-wash-out-effect causing severe cardiac arrhythmias. Isoflurane maintenance concentrations vary - dependent of different bird species - between 1,0 Vol. % to 2,4 Vol. % (Columba livia Gmel., 1789). Pulsoximetry is indispensable as APA causes a reversible apnoe due to reduced CO_2 partial pressure causing a missing stimulation of the respiratory centre. Advantages of APA, a long period anaesthesia, which is used for routine ophthalmoscopy, electroretinography and head surgery in birds, are free surgical access to the head for intraocular surgery, stable or decreasing intraocular pressure and reversible apnoea with an absolute immobilisation of the patient. Achievement of mydriasis for ophthalmoscopy may be optimized by systemic administration of 0,2 mg/kg BW of the muscle relaxant Vecuronium which allows a complete mydriasis and areflexia with a lag period of approx. 26 sec. and a duration of 25 6 min. in pigeons (Columba livia Gmel., 1789) and a reduction of isofluran consumption of approx. 25 % at the same time. This technique allows examination even of the very lens periphery with the annular pad and the extreme fundus periphery.

APA - PRINCIPLES

- Anaesthesia induced mydriasis and free surgical access to the head area
- Perfusion of lung-airsac-system with oxygen-(nitrous oxide)-isoflurane or sevoflurane mixture
- Retrograde perfusion via left caudal thoracic air sac using a specific air sac catheter
- Induction of a reversible apnoea due to lowering of the CO_2-partial pressure with subphysilogical values (below 48 mm Hg; no stimulation of respiratory centre)
- Modified anaesthetic machine with low flow flowmeter (0.01 – 0.5 l/min)

APA – Performance

- Carrier gas O_2
- Induction: Head chamber
- Maintenance: Air sac catheter
- Isoflurane concentration: 1.0 - 2.7 Vol.%
- Monitoring: Pulse oximetry (!, no respiratory movements), reflex score, blood gases, body temperature

APA – Advantages

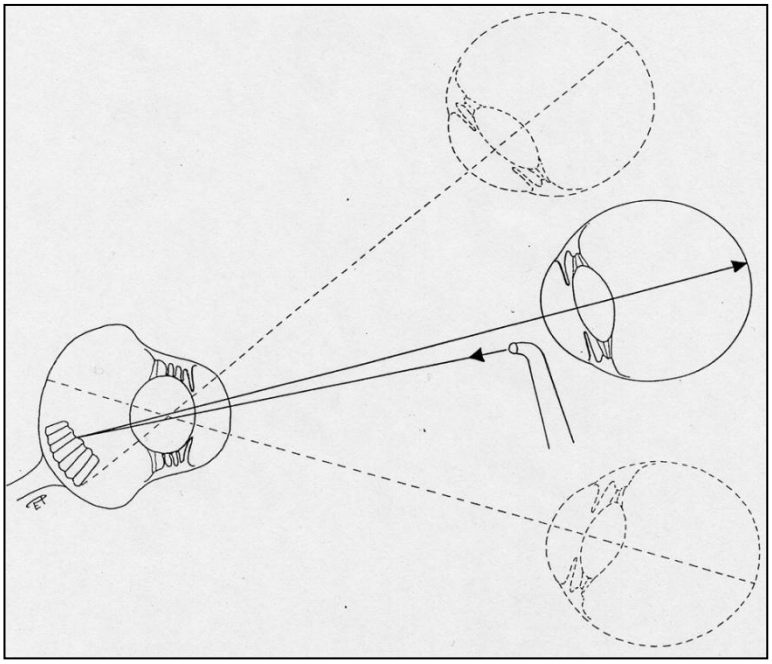
- Routine method for ophthalmology and head surgery
- Benefits of inhalation anaesthesia and long period anaesthesia
- Free surgical access to the head

- Stable or decreasing intraocular pressure (IOP)
- Reversible apnoea – absolute immobilisation of the patient
- Achievement of mydriasis for ophthalmology

Ophthalmoscopy in birds

Ophthalmoscopy, a technique to examine the fundus oculi (a clinical term, describing ocular structures, which are situated behind the lens) using a focussed light beam reflected from the fundus, can be carried out by both monocular and binocular and direct or indirect ophthalmoscopy in combination with double aspherical ophthalmoscopy lenses (at 30, 40, 60, 78 and 90 diopters (D, Volk Bio II) refractive power. In all cases indirect binocular ophthalmoscopy using a head ophthalmoscope is advisable. A 30 D lens is used in birds with larger pupil diameters (nocturnal and diurnal raptors), ophthalmoscopy of pigeons and larger psittacines requires an 78 D lens, those in small birds (canaries, budgerigars) the use of a 90 D lens. Alternatively, monocular indirect ophthalmoscopy may easily performed in all birds, especially in smaller species. It should be pointed out that within a long term survey including more than 32 % of traumatised birds showed haemorrhages in the vitreous body originating from lesions of the pecten oculi. Thus ophthalmoscopy is obligatory in traumatised birds.

Fig. 1: Optical principles of the (monocular direct) ophthalmoscopical examination of avian eyes. Per definition „ophthalmoscopy“ is the examination of ocular structures situated behind the lens, using a focused light beam directed through the pupil and performing the examination using light, reflected from the fundus oculi. As a rule, a nearly coaxial direction of the light beam directed through the (dilated) pupil (Mydriasis) of the patients eye (left) on the one hand and the reflected light beam from the patients fundus to the examiners eye (right; viewing axis) on the other hand is indispensable in order to project an image on the examiners retina (Taken from 4)



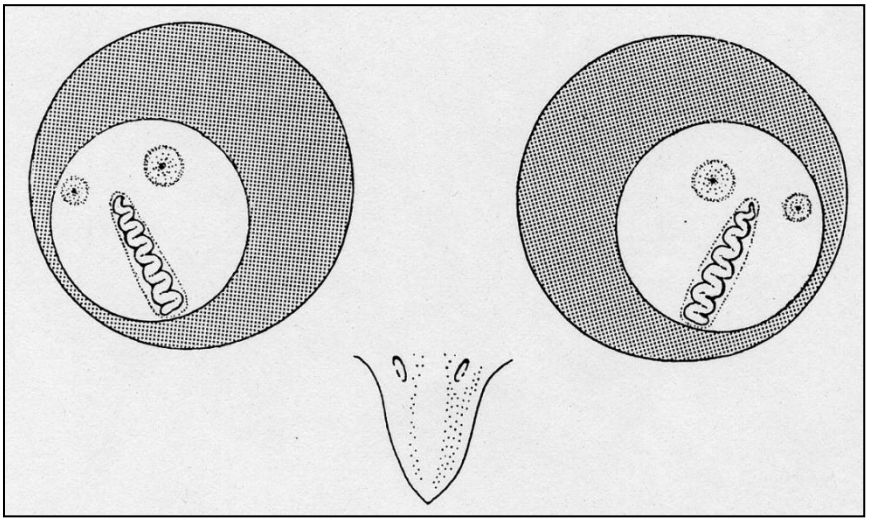


Fig. 2: Topograpical landmarks within the avian fundus with the pecten oculi and the central and temporal fovea. Accessible viewing field (bright area) using monocular direct ophthalmoscopy (taken from 4).

Ocular disorders in birds

The ophthalmologist considers it logical to classify eye disorders according to the various ocular structures involved. Thus a complete review on avian ophthalmology discords based on a morphological basis will be given within the presentation, for a literature review please refer to 1, 2, 3 and 4. Within a long period investigation on ocular disorders in birds (2) an overall incidence of 7.6 % of all the birds examined has been found. The highest incidence of eye disorders compared with other patient groups was generally found among wild birds (11.7 %), among which most eye disorders were seen in Accipitriformes (26.1 %), Strigiformes (20.0 %), and Falconiformes (19.7 %). In contrast, a lower incidence was found in falconry raptors with 7.3 %, but again Accipitriformes (6.3 %) were most frequently affected by eye disorders, followed by falcons (5.5 %) and owls (5.0 %). Among disorders of the posterior eye segment (fundus oculi) most often trauma related haemorrhages (most frequently arising from the pectin) may be diagnosed. In general chronic lesions caused by disorders located within the upper part of the fundus are resulting in a poor prognosis, as birds and especially raptors are orientating themselves primarily using the upper part of the fundus (with the central and temporal fovea included).

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Avian Orthopaedic Surgery

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Avian patients bring with them a range of challenges, in terms of size, pneumatised bones, thin cortices, brittle bones, compound fractures, metabolic bone disease, carapace injuries.

This lecture and practical course will major on the avian patient, as these present the greatest challenges with thin brittle bones and an active life style. The principles developed in avian surgery will then also be applied to the other genera, with life style and anatomical specialist requirements being explained and developed.

AVIAN ORTHOPAEDIC SURGERY

Wild birds of prey are one of the commonest groups of birds presented for fracture repair. Previous surveys of wild raptors trauma cases (Howard and Redig 1993), have shown that 33% are likely to have suffered a fracture incident, of these 40% are likely to be euthanized on account of the fracture, 10% euthanized for other reasons, and 15% die spontaneously. The percentage of wild raptor fracture cases that are eventually released is 36% for closed fractures, but only 15% for open fractures. The author believes strongly that permanent flight impaired wild casualty birds, of any species, should not be maintained in captivity, but should instead be euthanized. Such release rates may initially seem low, however it should be realized that for a wild bird to allow itself to be caught, it must be either severely traumatised or significantly weakened as a consequence of fracture, such that it has been unable to feed for several days. Wild raptor fracture cases are made up of 86% wing fractures (Howard and Redig, 1994), whilst in captive raptors 82% are leg fractures (Forbes unpublished data). The success rate for full return of normal function in captive bird fracture cases is far greater, predominantly because less are compound fractures (firstly because they are presented more quickly but also because less involve the humerus, where fractures are typically open), but also because correct expedient therapy can usually be implemented.

The approach to an avian orthopaedic case, requires initial consideration of the following key factors, is it a wild or a captive bird, is complete repair and return of normal function possible, and what degree of functional disability is acceptable for the species and individual bird to live a compassionate future life.

In considering the likelihood of return to full normal function, the following factors should be considered. Throughout the process, one should continue to ask oneself, if there is any reason why this bird will not be able to return to the wild, to hunt kill and survive in a wild environment. One of the first and most important considerations is eyesight. Many thin birds are admitted, which gain weight rapidly, are released and subsequently starve again. Likewise, it is known that 30% of raptor trauma cases have eye damage, of these the damage is only affecting the posterior chamber. Such damage is not apparent to the keeper, (or to the vet unless they pick up an ophthalmoscope). All raptor trauma or thin bird cases should have their eyes fully examined, and should preferably be flight trained and hunted prior to release, to ensure that they will be able to survive in the wild. Any bird that has lost an eye (or the use in it), a wing, leg, beak, first or hind talon or who is imprinted should not be considered for release to the wild.

How did the fracture occur, consider trauma, pathological fracture due to neoplasia, metabolic bone disease, osteomyelitis (in particular *M avium*). If it arose subsequent to trauma, have other structures also been traumatised. Which bone is affected? Compound or closed, avian bones have a wide medulla and thin cortex (in order to minimise weight, in order to maximise flight ability). Avian bones are brittle, they are surrounded by only a small amount of soft tissue, hence many fractures are compound (62% of all wild raptor fracture cases,) (Howard and Redig 1993), soft tissues, especially of the wing are prone to desiccation. If compound, how contaminated or devitalised is the potential surgical site. Is there significant soft tissue damage. Is nerve and vascular supply intact. Does the fracture involve a joint or is it close to a joint. After due consideration, if the case is to be treated, rather than euthanized, the condition of the bird must be assessed. Many birds which have undergone sufficient trauma to fracture bones will at the same time have suffered considerable other soft tissue damage. Pre anaesthetic screens performed and supportive care administered if appropriate (Redig, 1996). Fluid imbalances must be corrected, the patient stabilised, analgesia and antibiosis administered, prior to surgery.

The aims should then be to:

- Treat contaminated or infected wounds.
- Preserve soft tissues, if necessary by applying splints or other dressings. In view of the extreme fragility of avian skin, and the small volume of soft tissue, special care is required in many cases to prevent desiccation of muscle and tendon tissues.
- To realign fractures or replace luxations.
- To rigidly stabilise the fracture site, preventing any movement or rotation, this may require a combination of surgical techniques together with a full understanding of the husbandry of the bird, such that it may be properly controlled during it's convalescent period.
- Maintain full early function of all joints and tendons.
- Return the limb to full normal function, without adversely affecting the healing process as quickly as possible.

An important point to remember is that wing amputee male birds are highly unlikely to ever successfully copulate. Leg amputee birds over 150g, almost inevitably develop bumblefoot or arthritis in their remaining foot sooner or later.

Timing of surgery

- It is the author's experience that all such orthopaedic cases should have surgery delayed by 24 hours. In the interim desiccation and further trauma should be prevented. The bird should be stabilised with fluid therapy, analgesia, antibiosis, parasiticides if necessary, and nutritional support.
- Timing and method should always be considered on an individual cases basis, decisions will vary depending on the nature and life style of the bird, let alone the fracture and the state of the proximate tissues.

Methods of Fracture Repair

- External coaption (splints, extension splints, bandages etc.)
- Internal fixation (pins, wire, cement, etc.), surgical intervention and trauma should be minimised
- External fixation (half or full pin, with lateral stabilising bars)
- Case and method selection should be made in consideration of the degree of perfection that that species requires in order to survive happily in the wild, or if a captive bird, for it to still be a functional bird for the owner in relation to its current or potential future uses. For example a hybrid 1 year old male bird, may be of very little use for anything apart from flying at game, whilst in contrast a female 6 year old pure bred gyr falcon, has great value and potential as a breeding bird, even if she cannot fly again.

Bone Healing

- In correctly aligned and opposed bones, repair is by endosteal callous
- If not rigidly fixed, periosteal callous will also form
- Stable properly aligned fractures heal more rapidly than in mammals typically being fully stable in 3 - 4 weeks

TECHNIQUES

Surgical approaches for avian fracture repair have been discussed by Orosz et al (1992), Harcourt-Brown (1994) and others. Orthopaedic techniques are very varied, depending on the bone, fracture type and the size and species involved. For surgical techniques the following references should be referred to (Howard and Redig, 1994; Hess, 1994; Coles, 1996; Harcourt-Brown, 1996, Gull *et al* 2012).

The current recommendations are in line with newer procedures in humans and domestic mammals. Surgical intervention, and in particular bone fragment manipulation at the fracture sight should be minimised or better still avoided. The aim should be to stabilise the fracture, in correct alignment and length, permitting full joint movements. This is often best achieved by the use of a hybrid or tie in fixator this involves the combination of a half pin external fixator, which is joined to a single intra-medullary pin (see later). Whilst avian fractures are least well suited to plate repair techniques, on account of the thin cortical walls, Gull et al 2012, have shown that 1.3mm mini compression plates, using at least 3 screws either side of the fracture and using a fine screw pitch (0.25mm), good results may be achieved. The authors quote the disadvantages as: cost, surgical complexity, post operative screw loosening. This technique is particularly useful in larger birds, especially for coracoid repairs.

Thoracic Limb

Coracoid: these fractures are relatively common, and are most often seen in sparrow hawks following collision with French Windows and similar. Good quality x-rays are required in order to exactly delineate the coracoid, furcula and scapula. Fracture of any of these may also result in disruption of the trioseum. Smaller species (<300g), generally respond well to immobilisation of the affected wing, and rest. (Northern Sparrow hawks in particular are very susceptible to stress, and the placement of bandages around the thorax can be deleterious. Larger species, especially those in which there is significant displacement, may benefit from fracture reduction and internal fixation (mini compression plate technique is recommended).

Proximal humerus: fractures commonly occur following similar injuries to those described above. Humerus fractures are the commonest type of fracture in wild raptors. The humerus is pneumatised, being joined to the clavicular air sac. Flushing of the proximal bone segment is dangerous in view of the possibility of encouraging infection to pass from the humerus into the air sac. These fractures are most commonly seen in the Northern Goshawk and Northern Sparrow hawk. These are best repaired with an intramedullary pin and tension band, linked to a hybrid fixator (see practical session for more details).

Mid shaft Humeral Fractures: these fractures frequently become grossly displaced and often (59%, Redig 1993) result in compound fractures, with exposed necrotic bone. For closed simple fractures of the mid shaft a simple hybrid fixator, with intramedullary pin placed retrograde or normograde, depending on the exact location and bone curvature of the patient. During surgery, great care must be taken not to traumatize the radial nerve, which is located just beneath the skin on the dorsal aspect. During repair great care must be taken to ensure the correct alignment of the humerus (best achieved with the bird in sternal positioning), mal-rotations can easily occur. As with many other long bones in avians, there is a great propensity for longitudinal cracking. Such cracks should be evident on x-ray (if of sufficient quality), so that circlage wires may be placed before i/m devices or external fixators are applied.

Distal Humeral Fractures: where there is limited distal bone length, a K wire, cross pinning (exit via fracture site and passed normograde), then reduced and retrodriven, prior to joining with ESF pins, to yield greater stability, is an ideal solution.

Dislocation of the Elbow: this injury, carries a poor prognosis for a post operative return to normal flight. Martin *et al*. (1993) described a half pin trans-articulation technique, which is applied for 7 - 15 days only, which achieved a fifty percent release rate in wild injured birds,

this author has achieved similar success rates with the same technique. An initial pin (a) is placed in the mid shaft humerus, (b) is placed in distal humerus, (c) is placed in proximal ulna and (d) is placed in mid shaft ulna. With the elbow flexed, pins (a) and (d) are joined and (b) and (c) are joined with ESF bars.

Fractures of the Ulna & Radius: 30% fracture only the ulna, 60% suffer fracture of the ulna and radius and 10% fracture only the radius (Redig 1993). These bones have little soft tissue support, the soft tissue being prone to desiccation. In birds with a fracture only the ulna if there is not significant displacement, then cage rest alone, (on occasions with bandage support - to maintain the wing in a natural position) is sufficient. In such cases the bird should be maintained in a 'night quarter' e.g. tea chest, so that it can move its wings but not extend or flap them fully, for a period of 2-3 weeks, although modern advise remains that fixation is preferable (half pin ESF or single i.m pin). If the radius is fractured, this does generally need to be stabilised by internal fixation with a single fine i/m pin. When repairing the radius the pin may be placed retrograde or normograde, as it can be passed out to the carpus without undue iatrogenic damage to the joint. If the ulna requires repair, a single pin is generally inserted in the proximal ulna just beyond the point of attachment of the triceps tendon i.e. gaining entry from the level of the 2nd or 3rd last secondary feather, on the dorso-caudal aspect of the wing. Circlage wires may also be necessary. In larger birds, especially if there is contamination of the wound (so foreign material at the ractuire site is contra indicated), an external fixator may be used.

During healing of fractures where the ulna and radius are involved, a synostosis may develop, if so careful surgery with an air drill to remove this and the placement of a fat pad (harvested s/c from the yolk sac – umbilical area) between the bones will often be effective in preventing reoccurrence.

Fractures of the metacarpals: these are often challenging as they are typically high impact injuries, with significant concomitant soft tissue damage. They may usually be repaired by external support (splints and bandages). Load bearing post repair (of primary feather forces when wing flapping) is demanding a considerable stability of repair. A single i/m pin is placed via the fracture site (on the ventral aspect – so as to avoid primary feather insertions), normograde, passing through the common metacarpo-phalnegeal joint. This is then bent through 90^{o} and joined to an ESF pin either side of the fracture on the dorsal aspect.

Angel wing is a condition seen most commonly in grazing waterfowl (e.g. geese), where excessive protein levels have been fed. This results in a dorso-lateral rotation along the longitudinal axis of the primary metacarpal bone. This may be corrected by cutting of the bone, placement of a single i/m pin, joining together with at least two ESF pins after correction of the rotation.

Pelvic Limb

Fractures of the Femur: these typically require surgical repair. The femur is pneumatised. Although 'Schroeder-Thomas' extension splints have been used in raptors, they are not well suited to them, and surgery represents a better method of repair. Femoral fractures most commonly occur, in flying accidents, when the bird is stooping at quarry which either goes through a fence or down a hole (e.g. rabbit). If there is subluxation of the coxofemoral joint, this will inevitably involve the femoral head, an arthroplasty should be performed. Proximal femoral fractures may be repaired with a tension band technique, but are then best joined to an ESF, with pins spread along the length of the femur, to yield significantly greater stability. Proximal to mid shaft fractures may be repaired as above. Distal fractures of the femur may be repaired using crossed K wires, then linked to ESF pins, as for distal humerus.

Fractures of the Tibiotarsus: these are by far the commonest fracture of captive birds of prey. The fracture usually occurs within the first three weeks that the bird is every restrained on a perch by the use of 'Jesses' (leather anklets). The fracture occurs at the junction of the first and second third of the tibiotarsus, within 3mm of the fibula crest. Repair is most commonly achieved with either multiple intramedullary stacked pins, inserted retrograde, exiting at the anterior aspect of the stifle joint, post operatively the chance of rotation about the longitudinal axis may be reduced by applying a box splint (made of foam backed aluminium finger splint), which is applied around the dorsal aspect of the distal femur, lateral and medial to the tibiotarsus, and ventral to the proximal metatarsus. Alternatively a hybrid fixator technique is used, with a single i/m pin, passed retrograde from the fracture site to the anterior aspect of the tibiotarsus, joined to four ESF pins (two either side of the fracture site). So as to minimise iatrogenic stifle complications, the i/m element is removed 10 days post surgery. The ESF pins are placed cranio-latero, rather than latero-latero, so as to minimise risk of damage to branches of the tibialis nerve, namely the tibialis medialis medially or the fibularis and suralis lateralis laterally, during pin placement. Following surgery to this bone, venous congestion of the distal limb is not uncommon. The author advises applying elastoplast on the distal limb at the time of surgery to prevent swelling.

Fractures of the distal Tibiotarsus: these may be repaired using the above technique or a cross pin method (as for distal humerus or femur). The surgeon should be aware of the position of the extensor canal in the distal tibiotarsus. If this structure has potentially been damaged, it is important that intertarsal joint movement is maintained during healing.

Subluxation of the tibial cartilage: can occur as a consequence of trauma or secondary to growth abnormalities, which may result in bowing of the tibiotarsus, or longitudinal rotation. In such cases the tibiotarsus should be sectioned, de-rotaed and repaired.

Fractures of the Tarso-metatarsus: these most frequently occur, when nesting material catches under an oversize ring in a young bird whilst still in the nest. The tarsometatarsus is made up of the distal row of tarsal bones, plus metatarsae 2, 3 & 4. Metatarsus 1 forms the proximal section of the hind talon. Hawks have no intramedullary cavity, whilst falcons have one in the distal half of the bone only. The posterior aspect of the tarsometatarsus is concave, (containing the flexor tendons), and hence care must be taken in using half or full pin

techniques, not to trap these tendons. Alternatively, a padded aluminium finger splint may be placed down the lateral side of the leg, and under the ball of the foot. Fractures of the distal tarsometatarsus, may involve the interosseal canal.

Chip fractures on the medial or lateral aspect of the distal tarso-metatarsus are not uncommon, the bird should be restrained in a dark small enclosure (eg Tea chest), but the foot and leg should not be dressed, as the tendons may become involved in the callous if the limb is immobilised. Clinically these will look similar to avulsion of the first metatarsus, or oedema following local trauma when first jessed up.

In severe bumblefoot cases, bacterial infection may lead to osteomyelitis, resulting in loss of bone density of the trochlea. All severe cases should be x-rayed for these signs and if present the bird should be euthanized.

Phalanges: any significant swelling should be considered serious and the foot should be x-rayed and compared with the opposite foot. Osteomyelitis is common as are fractures. Fractures may be treated with rest alone, or the foot may be placed in a ball bandage for the first 7 days only. Any lengthened period of immobilisation, or attempted immobilisation of only one toe will end in a disaster. Infection in the tip of a toe, just ventral to the junction of the toe with the claw, can easily lead to infection of the distal interphalangeal joint, at the site of the insertion of the flexor tendon, which will lead to the necessity for partial or complete toe amputation.

Hybrid fixator (ESF-IM tie-in)
As mentioned above this is the most widely recommended technique for many avian fracture cases. Any device inserted should promote load sharing. as healing progresses, parts of the fixator may be removed, a process referred to as dynamic destabilization (Redig 2000).
The technique has been present in various forms for a number of years. It was refined and further developed (Redig 2000), as an answer to provide longitudinal and rotational stability to humeral fractures, without having to resort to total wing fixation. With good fixation and good overall vascular condition at the fracture site, healing will often be achieved in 2.5 - 3.5 weeks. However on many occasions when vascular function is impaired, or there is significant trauma related tissue damage, full repair may take several weeks. Loosening of pins should not occur, and the use of positive profile pins greatly assists in prevention.

In simplistic terms, a single i/m pin is placed along the full length of the bone, but avoiding any damage to or full functioning of the joints. External fixator pins are then placed in safe sites (to avoid major blood vessels and nerves or contusion of tissues in subsequent limb movements), with at least two other side of the fracture, spread out as far as possible along the length of the bone. The free end of the intra medullary is bent through 90o and attached to a bar which in turn joins with all the external fixator pins, there by linking i/m and ESF.

Developmental Problems - rickets is still common and is always associated with a Ca:P:D_3 imbalance.

The bones affected will be dependent on the age of the chick at the time of deficiency. Chicks may hatch and be deficient. This occurs if the hen laid a deficient egg, as a result of dietary (or ultraviolet light) deficiency, renal or parathyroid disease. These chicks are weak, may have a defective hyoid apparatus, and have swollen epiphysis. Bowing is most often present in the tibiotarsus at the level of the fibular crest, although in severe cases, the femur, ulnar, radius, humerus, ribs and pelvis may be affected. Cases with marked clinical signs are generally hopeless. Others may have less severe signs which may comprise tarsal valgus or varus, tibial head dyschrondoplasia, or longitudinal rotation around the length of the tibiotarsus.

Long bone deviations should be corrected as soon as possible. When very young and the bones are still soft this is best achieved with closely applied aluminium finger splints. These should be applied under general anaesthetic. The clinician must be mindful of the very fast growth rates achieved at this stage of life, and such splints will need to be changed every 2-3 days. Typically 1-2 changes are all that are required, as bone healing is rapid. Growth restriction (through controlled food intake), Ca & D_3 supplementation is crucial. Once splints are applied, the chick must be restrained so that undue pressures do not develop at the end of the splint (this is not uncommon). Young chicks may be suspended in a plastic box filled with wood shavings, until such age as they attempt to crawl out of this all the time. .

If a juvenile bird is presented with deviations of long bones (distal tibiotarsus is one of the commonest sites), then all bones should be assessed in relation to their longitudinal alignment and correct alignment. surgery is typically indicated, but before embarking on this one must assess how many bones will require correction, and if any can be performed simultaneously. One should consider the welfare aspects to the bird of repeated surgeries, the likely final outcome and the costs before one commences.

X-rays of young birds may prove confusing and difficult to interpret. The epiphysis are cartilagenous, and do not become radio lucent until growth has stopped at which point they mineralize. The distal tibiotarsus and proximal tarso-metatarsus may look as though they have a mammalian growth plate but it is in fact only the tarsal bones giving this deception.

Tarsal varus or vulgus, may also occur after damage to the growth plate of one of the metatarsae, but not the others. Treatment comprises removal of the damaged cartilage, correction of the angulation of the bone and restraint in a cast for 10 days.

Osteoarthritis: is rare in birds, usually following chronic inflammatory joint disease caused by untreated conditions such as femoral head fractures, pins left in joints or developmental / growth abnormalities. If mal-alignment is present, then one should consider if this should be corrected.

Scissor beak: this can seen in many species and is easily recognized. The key is that correction must be effected before the bird's beak becomes hardened. Initially coping and physiotherapy may be tried, but if not effective within 14 days, a dental acrylic ramp should be created. This is fixated on the lower beak, on the side to which the top beak deviates. In this way, as the beak closes, the top beak hits the

ramp and is pushed back towards the centre. Placing any rigid structure on a flexible beak, means the prosthesis will come off within 10 days, warn the owner of this. Typically 10 days correction is sufficient to resolve the problem.

Bragnatism: this is where the top beak closes inside the lower beak. Again physiotherapy can be tried initially. If the problem does not resolve, then an extension will need to be created to the tip of the top beak, so that as it closes, the beak is pulled forward. Again within 10 days the beak will correct – so long as correction is attempted before the beak has become hardened.

Split Mandible: this is an infrequent but critical and urgent injury. The mandible will require repair, any soft tissue reattached and the repair supported. This will typically be achieved, with a cross mattress suture, over laid both inside and outside the mandible with dental acrylic.

Angel Wing: this is most commonly recognized in geese and swans, but may also be seen in raptors and other species. Swans and geese are designed to grow slowly on a diet of 17% protein content (i.e. grass), if they are fed cereals or bread they grow too fast and the problems develop. The problem occurs due to a differential growth rate between bone and tendon, such that as the primary feathers start to form, they rotate away from the body, due to a twisting of the common metacarpal bone. If recognized early, the problem is resolved by reducing the rate of growth (in particular reducing the protein content of the bird's diet, but also the volume) and strapping the bird's wing against the body. Doing this for a three day period will typically effect normality.

If the problem is only recognized in an adult bird, then an osteotomy, intramedullary pin and de-rotation of the distal wing, will return normality.

Metabolic Bone Disease: this is caused by an abnormality in the Ca:P:vit D_3 content of the diet. This may relate to renal damage of the hen, lack of UV light for the parents, incorrect diet (too much muscle and no bone in a raptor, or too many pulses and protein in a psittacines). The faster the bird is growing the more critical is the correct ratio. At all times grow (especially large long legged birds very slowly). If a chick is presented with MBD, internal fixation is not possible as the bone is so soft. Instead external splints and if necessary slinging the bird (to prevent weight bearing on legs), but beware weight bearing on flexible ribs with the effect of cardiac compression. In the latter cases, provide a restricted diet, with added Ca and D_3, for 3-4 days prior to slinging.

Correct the diet (Ca:P:vit d3), slow down the rate of growth and assess the whole body. Always consider the birds welfare and do not attempt surgery unless the alternate leg can cope during the recovery phase.

Splay Leg: is caused when birds grew up nesting on a smooth surface. If detected early, using tape hobbles, rearing in a round bottomed bowl, or taping legs inside a drinking cup, i.e. anything to get the legs back into a biological position, will effect normality, so long as long bone growth has not finished. If the bones have finished growing, the only option will be multiple osteotomies and de-rotation. In such cases the bird's welfare needs to be carefully considered.

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Avian Orthopaedic Surgery: Practical Sessions

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1. TIBIO TARSUS – HYBRID FIXATOR

Commonest fracture of captive falconry birds. The fracture is typically at the junction of the first and second third of the tibio tarsus. With the bird in lateral recumbency (on the side of the effected leg), incise the skin on the medial aspect of the distal tibio tarsus.

Split the aponeurosis between the tibialis cranialis and the medial head of the gastrocnemius. Take this division proximally until you reach the fracture site. Locate the proximal fragment. Pick up the proximal fragment with a pair of rat tooth forceps, then place a fine pair of artery forceps into the medulla.

Locate a suitable length and diameter (1/4 – 1/3 of diameter of medulla, but not so thick that bending it would be difficult), straight unthreaded pin. Cut any point off the distal end of the pin.

Place the pin into the medulla of the proximal fragment, advance retrograde. Flex the stifle and angle the pin as far anterior as possible, to exit the proximal tibiotarsus, in an anterior position.

Once the pin is exteriorized at the stifle, pull it retrograde, so that only 3mm or so, is still protruding from the fracture site. Locate the distal fragment. Lift proximal and distal fragments ach with a pair of rat tooth forceps. Tent each end up at 15-20^{o} to the horizontal and engage the pin in the distal fragment. Reduce each to the horizontal, place finger and thumb across the fracture site to stabilize, and pass the i/m pin into the distal fragment. Push the pin until further advance is impaired. Take an identical pin and measure length against that in the bone, to ensure the i/m pin is correctly positioned.

Close the skin, with vicryl rapid 3/-0 4/0 or similar.

Next move the bird over, into lateral recumbency on the other side, so that you can access the lateral aspect of the effected limb.

You now need to place 2 ESF pins, above and 2 below the fracture site, placing then on the cranio lateral aspect of the leg. Threaded pins have superior holding ability, but positive thread is no better than a negative thread in birds.

Always place pins with a powered hand drill. Insert the pin end through the skin and engage the cortex. Clamp the surrounding soft tissue between finger and thumb either side of the bone, before you engage power. Keep a finger directly behind the bone, to steady and feel for pin exit from the distal cortex. Once the pin exits the distal cortex, cease power drill and cut the pin or release from the chuck. Take care not to strain the hold the pin has in the cortex.

Next clamp the i/m pin, with wire twisters near the exit from the stifle. Place the chuck on the emerging pin distally and bend the pin through 90 degrees without placing any strain on the cortex.

A line the i/m pin and the esf. Connect with a further pin, wire in place. Cut off any sharp extremities (careful not to damage eyes with flying ends), then set with technovit or other acrylic.

2. TARSO-METARSUS – FULL PIN EXTERNAL FIXATOR

The tarso-metatarsus does not benefit from an intramedullary space. Place a sterilized length of tubing each side of the tarso metatarsus. With powered drill, pass unthreaded pins through tube, bone and further tube on the other side. Keep tubes at least 7mm, from the soft tissue of the leg. Fill each tube with technovit. The lateral bars can be strengthened if deemed necessary, by placing an additional pin in the tube, prior to filling with resin.

3. PROXIMAL HUMERUS – PIN AND TENSION BAND LINKED TO AN ESF

This fracture is commonest in flying / wild birds. It is a challenging fracture, often occurring at the distal edge of the pectoral crest on the humeral head.

The humerus is approached via the lateral aspect. The radial nerve traverses the body of the humerus from medio-proximal to distal lateral aspect and can normally be seen through the skin. Advance proximally to the fracture site. Identify the deltoideius minor (dorsal aspect of the pectoral crest) and the coracobrachialis cranialis on the ventral aspect of the pectoral crest.

Pass two fine unthreaded pins from the fracture retrograde (one either side of the crest), towards the shoulder joint. With the wing closed against the thorax wall, pass the pins out of the proximal humerus, one each side of the pectoral crest. Drill a hole cranial to caudal, parallel to the fracture, 5-10mm, distal to the fracture. Reduce the fracture, and push the two pins normograde (the full length of the humerus), into the distal fragment. Now place a figure of 8, tension band wire. In front of the pins as they exit the proximal humeral head, cross the wire over at the base of the pectoral crest, then pass through the drill hole in the cortex of the distal fracture fragment. The wire should be tightened bilaterally, to keep the tension even.

Now take the pins linked to the tension band, and bend then through 90^{o}. Then place two pins through the distal humerus, being careful to avoid the radial nerve, spreading them out over the length of the bone. Join i/m pin with esf pins.

4. DISTAL FEMUR OR HUMERUS

Access the fracture on both sides. Place a fine plain pin (cross pin fashion, from fracture site, diagonally into the distal fragment. Reduce the fracture and retrograde the pins. If possible allow pins to contact 3 cortices. Then bend pins up and tie in to hybrid fixator.

Prevalence of Faecal Endoparasite Ova in Falcons in Qatar

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Introduction

The Souq Waqif Falcon Hospital (SWFH), Qatar, is a dedicated falcon hospital, established in 2008, to service the falcon shops at the souq, in addition to privately-owned birds. As a government institution, many of the services are heavily subsidized in order to make advanced diagnostics accessible to all falconers. As a result, the hospital receives an average daily case load of 50 falcons (42%Peregrine falcons, 38% Saker falcons, 15% Gyr and Gyr-hybrids, 3% Lanner falcons and 2% Barbary falcons in 2011-12) during the hunting season from September to March. The subsidy on services and treatment is also quite effective in encouraging falconers to screen their birds regularly for endoparasites in faecal samples as a preventive health measure during this stressful period.

Methods

During the hunting season from October 2011 to April 2012, 6853 faecal samples from captive falcons were evaluated for endoparasites at SWFH. The routine faecal parasite examination was carried out by the direct examination of wet mount preparations of fresh faecal samples under 100X (10X objective) magnification. The results were recorded under 4 broad categories- Coccidia (*Caryospora* spp), Capillaria, Serratospiculum, and Trematodes/Others (consisting mainly of trematodes and few ascarids, acanthocephalans, etc). The categories were based on pathogenecity and treatment considerations.

In each sample the parasite abundance was loosely estimated and graded subjectively from 1+ to 4+ (Table1).Any repeat samples from one bird on a particular day was recorded as one sample, but the same bird returning another day for a faecal check was recorded as a new case. For the purpose of this study, all faecal samples showing gross abnormalities, including worms, in the absence of parasite ova, were considered negative.

Results

Retrospective analysis of the faecal records revealed that 35.7 % (2449/6853) of the samples examined were positive for one or more endoparsite ova. A monthly break-up showed that the prevalence of endoparasites was highest in the month of November, at 40.9%, and lowest in January, at 31.5%. When the relative prevalence of the different categories of parasites recorded at SWFH was analysed, Coccidiosis was by far the most common endoparasitic infestation, with oocysts of *Caryospora* spp. detected in 53.6% of the positive cases. Prevalence of coccidiosis during the study period was 19.2%. This was followed by Trematodes/Othersdetectedin29.5%, Serratospiculum in 21.6%, and Capillaria in 13.2% of the positive cases. 519 of the 2449 cases (21.2%) concurrently tested positive for two or more types of endoparasite.

Serratospiculiasis had a prevalence of 7.7% (529/6853 samples). A deeper scrutiny of the Serratospiculum species positive cases revealed a definitive trend over the months examined, with a maximum of 10.8% (129/1188) in the month of November, declining progressively over the next few months to 3.25% (100/307) by April 2012. Records were available for 187 out of 457 samples that were positive for Serratospiculiasis. Of these, 13 were repeat samples from the same bird, therefore174 record files were analysed. Within the Serratospiculum positive group were predominantly Peregrine falcons (51%), followed by Saker falcons (40%), Lanner falcons (5%), Gyr and Gyr-hybrids (3%), and Barbary falcons (1%). During the examination period, only 14 birds were recorded as having a heavy infestation of Serratospiculum spp. (4+), of which 57% (8/15) were Saker falcons.

Discussion

Endoparasites, a common finding in free-living raptors, assume a greater clinical significance in captive birds, especially under compromised management conditions, concurrent disease and stress (Forbes, 2008). At a falcon hospital in Saudi Arabia, endoparasitism was a major contributor to morbidity in captive falcons, with a prevalence of 32.9% (Naldo and Samour, 2004). Of the common endoparasites in raptors, nematodes are the most common, potentially pathogenic, group (or phylum) of endoparasites, with the notable exception of protozoa. In fact, a number

of different studies in the Middle East have established Serratospiculiasis as the most widespread parasitic disease of captive falcons (Al-Tamimi, 1987;Samour and Silvanose, 2000; Samour and Naldo, 2001).

With the percentage of endoparasite positive samples at 35.7%, the findings of this study corroborate those of previous ones on the prevalence of endoparasites in captive falcons. The maximum prevalence recorded (40.9% in November) coincided with the peak hunting season period in Qatar, most likely a result of the extreme demands placed on the birds by the rigours of hunting. In contrast to published literature, the most commonendoparasite encountered in this study was coccidia or Caryospora species, not serratospiculiasis. The pattern of monthly prevalence of Coccidia mirrored that of total endoparasite prevalence with increasing prevalence rising to 21.6% by December before decreasing again to 15.9% by April.

This study also recorded the lowest prevalence (7.7%) of serratospiculiasis to date. The fact that data from only one part of the year has been analysed might account for this, although a seasonal variation in prevalence of serratospiculiasis has not been reported so far. Alternatively, the detection method used in this study was examination of a direct smear, a less sensitive technique than faecal flotation for the detection of parasite ova. Despite these limitations, these results appear to follow an interesting trend apparent in recent publications on the prevalence of serratospiculiasis in captive falcons. A review of published literature on the subject, especially in the Middle East, published between 1984 and 2001 reveals a prevalence ranging from 35-70% (Greenwood et al., 1984; Al-Tamimi, 1987; Samour and Silvanose, 2000; Samour and Naldo, 2001), whereas studies published in the last decade report much lower prevalences of 8.7% (Tarello, 2006) and 18.9%(Al-Tamimi et al., 2009), in Kuwait and Saudi Arabia, respectively.

The probable reasons underlying this apparent decline in the prevalence of Serratospiculum species include the increasing use of captive-bred falcons in falconry and, more likely, especially in Qatar, the widespread and unregulated use of anti-parasitic drugs like ivermectin by falconers and falcon traders. Although Peregrine falcons accounted for most of the Serratospiculum positive cases in our study, in contrast to Saker falcons reported elsewhere (Al-Tamimi, 1987; Samour and Naldo,2001; Forbes, 2008), caution must be exercised before drawing any conclusions from this data since records with species information were not available for all the faecal samples examined in this study. The results may well be a reflection of the relative numbers of these species received at the hospital.

In conclusion, the results of this study, albeit preliminary, have yielded some interesting findings that highlight areas for further research. Narrower categories for recording results of faecal examination have been introduced at SWFH, especially since the Trematode/ Others group was found in 29.5% of positive cases. In addition, there appeared to be a close association between incidence of Trematodes and Serratospiculiasis (approaching 40% in some months) that needs further investigation. Further, given the volume of samples examined at the hospital, analysis of year-round data and comparison of season and out-of-season data, as well as the sensitivity of faecal examination methods will definitely augment the existing body of knowledge on the subject.

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TABLE1. Explanation of grades used for estimating parasite ova abundance in direct smears at SWFH (Note: Only the area under the cover slip is examined).

Grade	Microscopic Findings (10X Objective)
1+	1-5 ova detected in the smear
2+	6-15 ova detected in the smear
3+	16-25 ova detected in the smear
4+	More than 25 ova in the smear

Trend of bacterial and fungal diseases in falcons in Qatar

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ABSTRACT

OBJECTIVE: To investigate the prevalence of bacterial and fungal infections and their antimicrobial sensitivity in falcons in Qatar.

DESIGN: Retrospective study. Animals - 560 falcons.

PROCEDURES: The swab samples, for bacterial and fungal screening, were collected from various sites and from abdominal air sacs through endoscopy using 2.7 mm diameter x 18 cm long 30^{o} telescope from falcons presented to the Souq Waqif Falcon Hospital during 2011-2013. Standard bacteriologic methods were used for each sample. MacConkey, Columbia CNA, Brucella and Sabourauds Dextrose Agar plates were used. Identification of Gram negative (GN) and Gram positive (GP), anaerobic (ANC) bacteria and yeast (YST) isolates and antibiotic sensitivity tests (AST) for GN (AST-GN38), GP (AST-GP69), and YST (AST-YST01) were performed using Vitek 2 Compact automated system and *Aspergillus* was identified by Biolog MicroStaion instrument. AST was performed for the majority of bacterial and yeast isolates but Aspergillus, using enrofloxacin, marbofloxacin, piperacillin, amikacin, clindamycin, flucytosine and voriconazole antimicrobics.

RESULTS: *Pseudomonas aeruginosa* was highly prevalent (25.7%) in 412 bacterial isolates than *Escherichia coli*, *Klebsiella pneumonia, Staphylococcus epidermidis, Enterococcus faecalis* and *Acinetobacter haemolyticus* (17.1%, 9.7%, 5.8%, 4.6%, 3.4% and 2.4%). The incidence of *Candida albicans* was higher (27.9%) than *Candida guilliermondii*, *Candida famata* and *Candida glabrata* and *Candida krusei* in 168 fungal isolates. The non Candida yeast isolated, *Cryptococcus laurentii* was 11.3% compared to 6.5% *Stephanoascus ciferrii*. *Aspergillus fumigates* was more prevalent than *Aspergillus flavus, Aspergillus brasiliensis* and *Aspergillus nodulans* (50.6%, 1.8%, 5.9% and 1.2%). Saker falcons appeared more susceptible to bacterial infections (48%) than peregrine falcons (40%) and gyr falcons (9%), peregrine falcons were more prone to yeast and fungal infections (64% and 47%) than saker falcons (25% and 35%) and gyr falcons (11% and 16%) respectively. The incidence of Co-infection involving bacteria and fungi was higher in peregrine falcons than saker and gyr falcons. Voriconazole 12.5 mg/kg PO, 12-24h for 14-21 days with piperacillin preparation 100 mg/kg IM, 12h for 7 days for treating early, intermediate and advanced cases of Aspergillosis, and yeast infections showed promising results in majority of birds. *Pseudomonas aeruginosa* was found to show more variability against the antibiotics tested within different birds.

CONCLUSIONS AND CLINICAL RELEVANCE: While *Pseudomonas aeruginosa, Escherichia coli* and *Aspergillus* produce indistinguishable granulomatous lesions, identification of the causal agent is required in the management of infection caused by these organisms in falcons. Indication of disease symptoms with the predominant presence of otherwise less virulent bacteria or non Candida species for example; *Proteus*, *Serratia*, *Sphingomonas* and *Kocuria species*; and *Cryptococcus laurentii* and *Stephanoascus ciferrii* should be taken cautiously. Further study is required to investigate any emerging pathoge