Incubation

Eggs can be either parent-incubated or artificially incubated. Many falcon breeders elect to allow parents to incubate the eggs and begin raising the chicks. Malfunctions are always a threat with artificial incubation and most breeders feel that the parents do a superior job. Artificial incubation does make sense if increased production is required, such as during species recovery efforts. Another alternative is surrogate incubation using another falcon hen or even chickens (*Gallus gallus*) (Savell, *oral comm.* Feb. 2008; J DeRoque, *oral comm.* Jan. 2008).

Paediatrics

Chicks are either raised by hand from hatch, from a period of about 10 days old, or entirely parent-raised. In the case of hand-raised birds, their natural conspecific-identity (imprintation) may or may not be preserved. Birds that are raised by their parents or at least with minimal human face, hand, and voice contact will be suitable for release to the wild or for sale to a falconer desiring a non-human-imprint raptor for hunting or captive breeding. There are concerns, by some, that the release of captive bred hybrid raptors could have an effect on wild populations. In the United States, hybrids cannot be legally released to the wild. Metal closed bands are applied to captive-bred eyasses to semi-permanently identify their special status.

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Enterocytozoon bieneusi infections in falcons: a new zoonotic disease

***Dr. Margit Gabriele Muller*[1]**

[1]Abu Dhabi Falcon Hospital/ EAD, P.O.Box 45553, Abu Dhabi, United Arab Emirates. vet_uae@hotmail.com

Introduction

Four falcons died due to liver and intestinal abscesses within 1 week. The cause of death was not clearly identified as all the falcons had visible yellow lesions on liver and intestines which appeared to be different from lesions of known diseases. The post-mortem was suggestive of a protozoal infection. Following a suspected disease transmission, all falcons from 3 different cages were caught and examined at the Abu Dhabi Falcon Hospital. Apart from other comprehensive examinations (Muller, 2007), endoscopic evaluations were performed in 137 falcons. These endoscopic pictures of *E. bieneusi* infections appeared to resemble the appearance of tuberculosis, salmonella or herpes virus infection, although the clinical picture is different for those diseases.

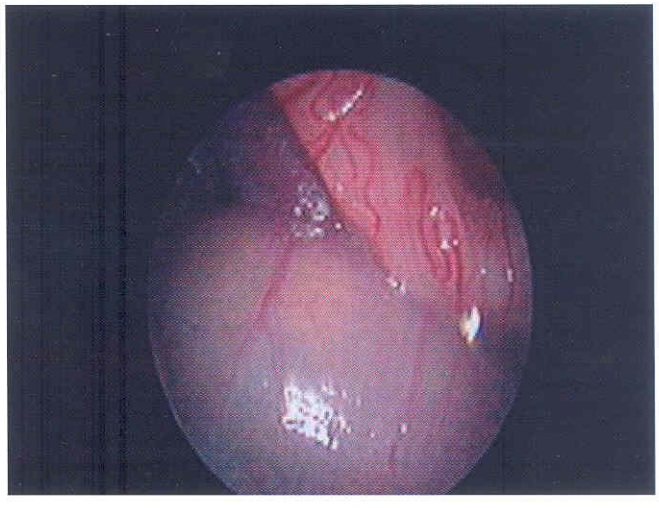

Figure 1. Intestinal abscess, early stage, as seen during endoscopy.

Treatment

The therapy of these sick falcons posed a major challenge as the cause of the disease could not be clearly identified at the time of treatment. All falcons were treated with Emtryl® 50mg/kg p.o. once daily for 10 days. Falcons with intestinal abscesses were treated after one week of rest with a further course of dimetronidazole (Emtryl®) at the same dosage for another 10 days. Those falcons suffering from intestinal, liver and kidney abscesses were treated additionally with special homeopathic medicines depending on the case (Muller, 2007). Medicines used in the presented case such as Nux vomica®, Mucosa compositum®, Hepar compositum®,

Berberis compositum®, and Cantharis compositum® have been successfully used in intestinal, hepatic and renal disorders in birds (Dorenkamp 2000). Coccidiosis was treated with Baycox® given for 3 days although usually two days treatment is sufficient. After one week another 2 days treatment were given if *Caryospora* sp. was still detected in the faeces. Probiotics® (Vetafarm) were given daily in the food after the Emtryl® therapy was finished (Muller, 2007).

A total of 117 falcons of the examined birds survived and showed abscess regression in the follow-up endoscopies after treatment. Twenty of the examined birds died within 6 weeks due to advanced liver, intestinal and kidney abscesses.

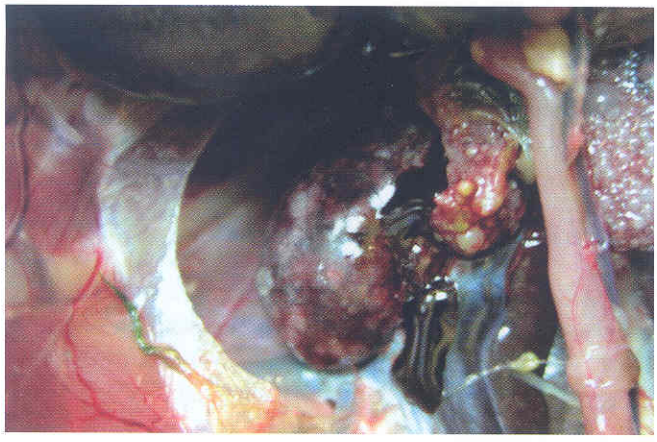

Figure 2. Kidney abscesses, advanced stage.

Detection of the Disease Pathogen

The liver samples from 6 randomly selected dead falcons were sent to the University of Vienna, Austria, for further investigation. Five of those selected falcons had clearly visible lesions and one without visible lesions. PCR for amoeba-DNA was negative. However, after 5 months, the presence of *Enterocytozoon bieneusi* with its human specific Genotype D was confirmed by PCR methods (Muller *et al.*, 2008). One PCR-positive falcon did not show any histopathological lesions suggestive for protozoal infection. However, it suffered from severe visceral gout.

What is *Enterocytozoon bieneusi* ?

The microsporidia *E. bieneusi* was detected for the first time in France in 1985 in an immunosuppressed AIDS patient with diarrhoea and isolated from the small intestine, especially the jejunum (Desportes *et al.*, 1985). Other risk groups are travellers especially from tropic countries (Lopez-Velez *et al.* 1999), as well as elderly people and children due to their reduced immune system (Lores *et al.* 2002b). *E. bieneusi* is the smallest microsporidia having spores of 1.2-1.7µm long (Canning, 1993). An infection of humans is thought to arise through inhalation, direct contact with mucosa and ingestion of the microsporidial spores (Haro *et al.*, 2005). Moreover, in humans a significant symptom of this microsporidial infection is diarrhoea accompanied by slow weight loss (Canning, 1993).
Detection in faeces is difficult due to the small size of the protozoa (Canning, 1993). One method is the detection of *E. bieneusi* by PCR with species-specific primers EBIEF1/EBIER1 (Da Silva *et al.*, 1996).

Implications for falconers

E. bieneusi is known to be present in domestic animals (Lores *et al.*, 2002a) such as rabbits, goats, pigs and dogs (del Aguila *et al.*, 1999). Infections of birds with *E. bieneusi* were reported for the first time 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). In 6 dead falcons from the presented group, *E. bieneusi* was detected by PCR methods. The identified genotype D has not been found in birds so far, but only in humans, macaques and pigs (Muller et al., 2008). Moreover, treatment for *E. bieneusi* infections has not been clearly specified yet in birds.

Figure 3. Intestinal abscesses, advanced stage.

The presence of *E. bieneusi* in falcons is a completely new parasitic and zoonotic disease which needs to be taken into consideration by clinicians. It might be possible that the captive-bred pigeons which live in the same farm as the falcons and are used as their food might have infected the falcons. Another possibility is free flying pigeons which might have flown over the falcons' aviary and transmitted the microsporidiosis with their droppings into the cage. Transmission from an infected human to the falcons might be possible, but could not be investigated. However, many caretakers of this particular falcon group originate from Asian countries. In travellers from tropical countries the presence of *E. bieneusi* infections is well-known (Lopez-Velez *et al.*, 1999). Therefore a transmission from possible infected staff to the birds following poor hygienic measures cannot be ruled out, especially as the genotype D is

reported in humans. The falcons suffered from immune suppression caused by predisposing factors such as overcrowding in the aviary and concurrent diseases such as aspergillosis. Most falcons also suffered from a lice infestation as well as massive *Caryospora* sp. burden. The latter had led to a severe damage of the intestines which might have paved the way to an invasion of the microsporidial spores. Moreover, the falcons from all three cages had been infected as identified by the PCR method thus leading to the assumption that a disease transmission had taken place from one cage to another. Furthermore, one falcon with *E. bieneusi* infection did not show any histopathological symptoms thus raising the question of possible disease carriers. It is still unclear for how long the *E. bieneusi* infection was present in the falcon flock.

Preventive measures

As the origin and transmission route of the *E. bieneusi* infection is not clear and requires further research work, still several preventive measures can be applied. It is highly desirable to enforce hygienic measures among caretaking staff and falconers including frequent hand washing and disinfection, as well as cage and falconry equipment cleaning and disinfection. Moreover, falcons with unclear endoscopic picture of internal abscesses should be tested by PCR methods for the presence of *E. bieneusi*. A strict separation of those falcons is highly recommended.

So far, it is not clear if the disease can be transmitted to falcons by infected humans. However, as prevention is better than cure, it is advisable to prevent any contact between falcons and caretakers suffering from diarrhoea. To avoid overcrowding in cages and to perform regular health examinations as well as to apply appropriate parasitic treatment are other important steps to prevent an immune compression in falcons and subsequently pave the way for *E. bieneusi* infections.

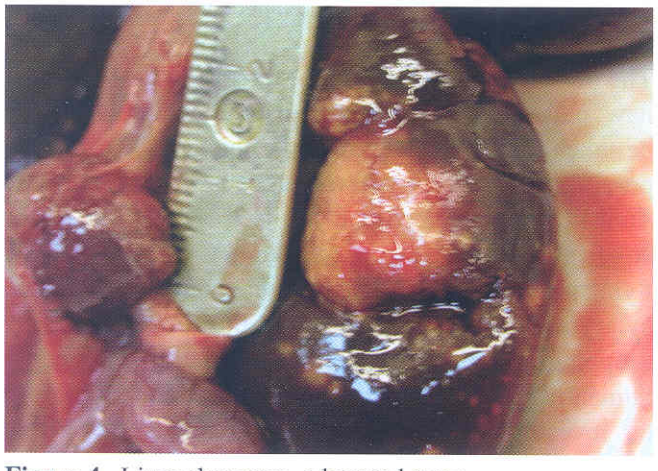

Figure 4. Liver abscesses, advanced stage.

Conclusions

The detection of *Enterocytozoon bieneusi* in falcons as a third confirmed susceptible avian species leads to the question of how many more raptor and avian species might be a host for this microsporidia and how many more falcons might have been infected unnoticed by 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, PCR methods should be performed for suspicious falcon samples.

Moreover, the zoonotic potential of the microsporidia raises the question to which extent falconers who live in close contact with their falcons might be at risk of a disease transmission from their birds. Further research is required to identify further affected avian species as well as the avian-avian, avian-human and possible human-avian transmission way.

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