Blood infections in falcons from Dubai: epidemiology, clinical signs and concurrent diseases

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SUMMARY

In order to document the epidemiology of Haemoproteus, Leucocytozoon, Babesia shortti, Aegyptianella spp. and Ehrlichia spp. infections, clinical signs and concurrent diseases in a population of 2282 captive birds of prey from Dubai, case records for all falcons with a diagnosis of intracellular haematozoa and bacteria were retrospectively reviewed. Sixty-five (2.85 percent) falcons received a diagnosis of intracellular haematozoa or bacteria: Babesia shortti (n=26; 1.14 percent), Haemoproteus tinnunculi (n=19; 0.83 percent), Leucocytozoon toddi (n=17; 0.74 percent), Aegyptianella spp. (n=7; 0.3 percent) and Ehrlichia spp. (n=2; 0.09 percent). Of these, 26 raptors showed a single infection whereas concomitant agents and/or diseases were identified in the 39 other cases (60 percent). This report highlights the dominant presence of Babesia shortti, and the frequent concomitant detection of other pathogens. Bumblefoot (n=7) and aspergillosis (n=4) were most commonly associated with B. shortti, suggesting a possible secondary opportunistic occurrence. Compatible clinical signs were seen in birds carrying B. shortti, H. tinnunculi and L. toddi as sole infection, thus confirming their pathogenicity.

Keywords: Falcon, raptor, blood infections, epidemiology, symptomatology, Leucocytozoon, Haemoproteus, Babesia shortti, Aegyptianella spp., Ehrlichia spp.

RÉSUMÉ

Hémopathies infectieuses chez des faucons de Dubai : épidémiologie, symptomatologie et maladies intercurrentes

Le but de cette étude était de décrire l’épidémiologie des infections à hémoparasites et bactéries intracellulaires tels que Haemoproteus, Leucocytozoon, Babesia shortti, Aegyptianella spp. et Ehrlichia spp., leur symptomatologie et les maladies intercurrentes observées chez 2282 faucons examinés à Dubai. Soixante-cinq (2.85 pour cent) faucons étaient porteurs d’hématozoaires ou de bactéries intracellulaires : Babesia shortti (n=26; 1.14 pour cent), Haemoproteus tinnunculi (n=19; 0.83 pour cent), Leucocytozoon toddi (n=17; 0.74 pour cent), Aegyptianella spp. (n=7; 0.3 pour cent) et Ehrlichia spp. (n=2; 0.09 pour cent). Parmi eux, 26 faucons ont montré une infection simple tandis que des agents/maladies intercurrents ont été identifiés dans les 39 autres cas (60 pour cent).

Les résultats de cette étude indiquent que les infections à Babesia shortti présentent l’incidence la plus importante et que ces infections sont souvent compliquées secondairement par d’autres agents pathogènes.

Des pododermatites ulcératives (n=7) et des aspergilloses (n=4) ont été diagnostiquées le plus souvent en association avec B. shortti, suggérant que la babésiose aviaire serait un facteur prédisposant à des maladies opportunistes secondaires.

Des signes cliniques ont été observés chez les oiseaux atteints d’une infection simple à B. shortti, H. tinnunculi et L. toddi, ce qui confirme leur pathogénicité.


Introduction

Of the many parasites affecting avian species, those belonging to the closely related protozoal genera Leucocytozoon and Haemoproteus (Apicomplexa, Haemosporida) are commonly detected in the blood of birds of prey [9, 17]. Prevalence of these haemoparasites has been investigated in many raptor species throughout Europe [12] and North America [8]. However such studies are rare in the Middle East [11, 15]. Pathogenicity associated with these haematozoa in Falconiformes remains controversial [6, 31, 32, 34, 35].

Tick-borne transmitted micro-organisms such as Babesia shortti [28], Aegyptianella spp. [29] and Ehrlichia spp. [30] have been occasionally reported in raptors from the Middle East. However, those previous studies mostly dealt with clinical and therapeutic aspects observed in the course of single infections. The aim of this survey is to describe the overall prevalence of intracellular haematozoa, concurrent diseases and clinical signs recorded in a large population of falcons from the Middle East.
**Material and Methods**

The study was carried out at the Al Wasl Veterinary Clinic, Dubai, United Arab Emirates (UAE), from August 2005 to October 2006. Microscopic examination for the presence of blood parasites was made on Diff-Quick-stained blood smears from 2282 captive falcons from UAE, including gyr (Falco rusticolus), saker (Falco cherrug), peregrine (Falco peregrinus), barbary (Falco pelegrinoides) and hybrid falcons (F. rusticolus x F. peregrinus and F. rusticolus x F. cherrug). Samples were taken from the brachial vein and 2 blood films obtained from each bird were stained and examined at light microscopy (x100). Intensity of infection was not calculated. Concomitant diseases and clinical signs were recorded as far as possible. Microscopic examination of fecal samples was performed in 100% and endoscopy in 70% of falcons. Biological samples from selected cases were sent to the Central Veterinary Research Laboratory (CVRL) of Dubai for pox and herpes virus isolation, testing for chlamydophthora and associated diseases and agents in falcons from Dubai.

**Results**

Sixty-five (2.85 percent) falcons were diagnosed with intracellular hematozoa (Table I). Twenty-six (40%) birds apparently showed a single infection whereas concomitant intracellular hematozoa (Table I). Twenty-six (40%) birds (n = 26; 1.14%) (n = 19; 0.83%) (n = 17; 0.74%) (n = 7; 0.30%) (n = 2; 0.09%) falcons (7 F. rusticolus, 4 F. peregrinus, 2 F. cherrug, 1 F. pelegrinoides and 5 hybrids). There were 12 pure cases, 2 non symptomatic and 10 showing reduced speed and strength in flight, in association with other concomitant clinical signs (Table II). Mixed infections (Table I) were diagnosed in 7 cases: Serratospiculum seurati (n=3), Leucocytozoon toddi (n=1), Pox virus (n=1), Trichomonas and Caryospora spp. infection (n=1), Trichomonas, bumble-foot and interstitial hepatitis (n=1).

**TABLE 1: Intracellular haematozoa and bacteria, and associated diseases and agents in falcons from Dubai.**

<table>
<thead>
<tr>
<th>Concurrent agents and diseases</th>
<th>Babesia shortti</th>
<th>Haemoproteus tinnunculi</th>
<th>Leucocytozoon toddi</th>
<th>Aegyptianella spp.</th>
<th>Ehrlichia spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>6</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Aegyptianella spp.</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bumblefoot</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Chlamydiophila psittaci</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ehrlichiosis</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trichomoniasis</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aspergillosis</td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Pox virus infection</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Herpes virus infection</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Leucocytozoon toddi</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Haemoproteus tinnunculi</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Babesia shortti</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Serratospiculum seurati</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Caryospora spp.</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trematodosis</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Amyloidosis</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Interstitial hepatitis</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**TABLE 1:** Intracellular haematozoa and bacteria, and associated diseases and agents in falcons from Dubai.
Results obtained in this study indicate that 2.85% of the falcon population in Dubai is infected with intracellular haematozoa, that *Babesia shortti* is the most common haemoparasite (1.14%; n=26), and that concomitant diseases/pathogens are generally frequent (60% of infections), particularly in association with babesiosis (77% of concomitant infections).

Clinical signs were present even in cases showing very low *Babesia* density: closed eyes, weight loss, anorexia, lethargy, vomiting, seizure, lowered head and blood in the mutes. Comparable clinical signs were seen in 6 cases with sole babesiosis (Table II).

Hyphomycetes infection (Figure 3) was found to infect 0.83% (n=19) of the studied sample, a small prevalence if compared with the results of studies carried out in Europe [10] and Egypt [7]. This may indicate a low local incidence of vectors for *Haemoproteus tinnunculi*, the ceratopogonid biting flies of the genus Culicoides [17]. There are 128 species of *Haemoproteus* that are currently believed to be host-specific to the family level [3]. They can affect a variety of birds of prey, with multiple infections commonly observed [10].

In a scale of clinical severity *Leucocytozoon* spp. infection generally ranks first, followed by *Haemoproteus* spp. [17]. In accord with the reported mild pathogenicity and the assumption that haematozoa may predispose to secondary pathogens is the observation that mixed infections with *Haemoproteus* were only diagnosed in 7 (37%) out of 19 cases (Table I), the lowest incidence found among haematozoa from the studied cohort. In the recent past, pathological changes and pathogenic effects have been increasingly reported in association with *Haemoproteus* infection in a variety of birds [5, 18, 27] and prolonged rehabilitation time and higher mortality rate have been seen in captive raptors with *Haemoproteus* infection [13, 35]. Compared to wild birds, in semi-domesticated animals such as captive falcons, pathogenic effects are easier to detect and are associated with host stress [32]. Pathogenicity was previously reported in 87.7% of *Haemoproteus tinnunculi* infected falcons from Kuwait and 83% of these experienced complete or partial recovery in association with disappearance (20%) or reduction in intensity of parasitaemia (63%) after oral treatment with primaquine, thus confirming that the clinical signs were linked to the *Haemoproteus tinnunculi* infection [32]. Accordingly, *Haemoproteus tinnunculi* was associated in this study with clinical signs in all cases presented as sole infection (n=12) but 2 apparently healthy birds (Table II). These were treated with artemether and lumefantrin (Riamet, Novartis) at pediatric

<table>
<thead>
<tr>
<th>Babesia shortti (n = 6)</th>
<th>Haemoproteus tinnunculi (n = 12)</th>
<th>Leucocytozoon toddi (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced speed &amp; strength in flight</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Weight loss</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Poor appetite</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Somnolence (closed eyes)</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Airsacculitis</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Finger paralysis</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Interstitial hepatitis</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Arthritis</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Seizure/convulsions</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Anaemia</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lethargy</td>
<td>2</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 2:** Clinical signs associated with intracellular haematozoa in falcons.

**Discussion**

This is in accord with the observation that the prevalence of *Babesia* in birds is greater than the record would suggest [17, 28] and that the high occurrence of mixed infections (77%) might be the result of a predisposing action for secondary opportunistic pathogens caused by the babesial persistence in the host organism [23]. Canine babesiosis is known to cause immune-dysfunctions which favour opportunistic infections [22, 23]. In this study, complex diseases such as bumblefoot (n=7) and aspergillosis (n=4) were most commonly diagnosed in association with *Babesia shortti*, possibly indicating a secondary opportunistic occurrence or a tendency in babesiosis to exacerbate concomitant agents. Previous report of concurrent occurrence of *Babesia shortti* and *Aspergillus fumigatus* ensuing fatal outcomes [20] agrees with such an hypothesis. Diagnosis of *Babesia shortti* is made by demonstrating the round to oval, 0.7-2.4 µm in size, non-pigmented parasites in the cytoplasm of red blood cells (Figure 1) [28]. Cruciform schizonts can be observed occasionally (Figure 2). As part of the broader study, TARELLO and YABSLEY [33] used molecular phylogenetic analyses to reveal that *Babesia shortti* is closely related (97%) to *Babesia poelea*, recently described in Brown boobies (*Sula leucogaster*), and that it belongs to the clade of piroplasms previously detected in humans and dogs in the western United States.

In 2003-2004, babesiosis was diagnosed in 1.54% of falcons from Kuwait [28], a prevalence similar to the one reported here (1.14%). However, cases with mixed infections were ruled out in falcons in Kuwait. The percentage of birds diagnosed with babesiosis was consequently higher in Kuwait, probably reflecting a higher proportion of wild-caught falcons in that area.

FIGURE 1: *Babesia shortti* organisms in some red blood cells from a reported case (x100).

FIGURE 2: Cruciform schizont of *Babesia shortti* in the blood of a reported case (x100).

FIGURE 3: Gametocytes of *Haemoproteus tinnunculi* (x100).

FIGURE 4: Macrogametocyte of *Leucocytozoon toddi* from a reported falcon (x100).

FIGURE 5: Large size *Aegyptianella* spp. inclusion body in a red blood cell in a reported case (x100).

FIGURE 6: *Ehrlichia* spp. organisms in the cytoplasm of a monocyte (x100).
doses [21]. Results indicate that this anti-malarial combination works better than primaquine in eliminating *Haemoproteus tinnunculi* parasitaemia and associated clinical signs in falcons [21], thus confirming once more that the signs observed are linked to the *Haemoproteus tinnunculi* infection.

In this study, *Leucocytozoon toddi* (Figure 4) was diagnosed from 0.74% (n=17) of falcons, a low prevalence when compared to that recorded from birds in Europe [9]. This may be due to the limited presence of intermediate hosts, the black flies of the Family Simuliidae [17], in the Middle East. The genus *Leucocytozoon* (Apicomplexa, Haemosporida) includes around 60 species of avian intracellular parasites and most of these are thought to be host-specific at the family level [3]. *Leucocytozoon toddi* has been recently associated with clinical disease and mortality in captive birds of prey [31]. The concomitant disappearance of clinical signs and of haematozoa from the blood shortly after melarsomine therapy indirectly confirmed that the pathogenic signs were linked to the presence of *Leucocytozoon toddi* [31]. Results of this study seem to confirm the pathogenicity rate previously noted in captive birds [2, 13]. In fact, all 5 raptors diagnosed with pure leucocytozoanosis showed compatible signs (Table II) including reduced speed and strength in flight (n=5), weight loss (n=3), anorexia (n=2), airsacculitis (n=1) and arthritis (n=1).

*Strigea falconispalumbi* (n=6) and *Serratospiculum seurati* (n=4) were the most common concurrent pathogens noted (Table I), possibly indicating a predisposing action for parasitic infestations due to Trematodes and/or Nematodes.

Recovery time from diseases and injuries is longer in rap-tors concurrently infected with *Haemoproteus* and/or *Leucocytozoon* [35] and this may reflect underlying subtle dysfunctions caused by the persistence of the haematozoa in the blood [19].

The absence of *Plasmodium* spp. recorded in this study may be due to lack of recognition and misdiagnosis of *Haemoproteus* [17]. Mixed infections due to *Haemoproteus* and *Plasmodium* are common. Differential diagnosis is required in such cases, but it may not always be possible to differentiate them when parasitemias are low [17]. Detection of *Plasmodium* sp. in 2 Egyptian kites (*Milvus migrans aegypticus*) recently examined in Egypt seems to confirm that these haematozoa are present in migrating birds of prey from the Middle East [7].

None of the falcons in this study were infected either with Haemogregarines (Apicomplexa: Haemogregarinidae) [19] or with *Trypanosoma avium*, a flagellate parasite of birds transmitted by mosquitoes and ornithophilic flies showing low host and geographical specificity [17]. Preliminary observations indicate that *Trypanosoma avium* is rare in falcons. Trypomastigotes were seen in the circulating blood of 0.7% of falcons from Kuwait [25]. However, in this study I used thin blood films which are not a sensitive diagnostic method for the detection of trypomastigote stages of trypanosomes.

*Aegyptianella* spp. micro-organisms ranging from 0.5 to 3 µm in size (Figure 5), were noted in 7 (0.3%) falcons in this study, including 2 cases diagnosed with pure aegyptianellosis showing signs such as arthritis, reduced speed and strength in flight, dyspnoea and diarrhea [29]. Concurrent disease most commonly recorded was babesiosis (n=4), in accord with the notion that *Aegyptianella* and *Babesia* spp. are both tick-transmitted diseases [17]. *Aegyptianella* spp. infection was previously diagnosed in 35 (2%) falcons from Kuwait [29] and 2 falcons from Italy [24] showing compatible clinical signs responsive to doxycycline therapy. *Aegyptianella* is common in the blood of birds imported from endemic tropical and sub-tropical areas [14] and most of the falcons visited in Kuwait and Dubai originated from and/or travelled periodically to endemic areas. Therefore, incidence and clinical appearance of aegyptianellosis reported here should not be controversial even though a differential diagnosis is required to separate *Aegyptianella* from early trophozoites and gametocytes of *Plasmodium* and *Haemoproteus* [17]. Usually, the microscopic examination revealed *Aegyptianella* inclusion bodies ranging from 1 to 3 µm in size and, in some cases, erythrocytes showed a protrusion at the site in which the inclusion body was located (Figure 5). Small bodies less than 1 µm in size were seen in some cases from Kuwait and Dubai as well, and whether these can be referred to as *Aegyptianella minitus* is not known, since this small micororganism was previously recognized only in the arboreal avian species *Alcippe peracensis* from south-east Asia [16]. Some inclusion bodies were pictured in the act of entering (endo-cyte) or exiting (exocytose) the membranes of the red blood cells.

The intracellular infection least commonly diagnosed in this study was due to monocytic *Ehrlichia* spp. organisms (Figure 6) found in 2 (0.09%) saker falcons. One bird was diagnosed solely with ehrlichiosis and showed compatible clinical signs, such as arthralgia, in-coordination and vomiting [30]. Concurrent babesiosis and *Aspergillus flavus* were seen in the second case, apparently confirming the occurrence in falcons of multiple tick-borne infections, often associated with opportunistic mycosis [20]. Diagnosis of ehrlichiosis was previously done in 4 (0.23%) Saker falcons from Kuwait based on the same criteria used for mammals [30]: cytological demonstration of inclusion bodies in monocytes (Figure 6), compatible clinical signs and response to doxycycline therapy. These inclusions bodies were identical to those previously reported in cats diagnosed with ehrlichiosis by this author [26].

The accurate diagnosis of blood parasites is time-consuming and requires good quality Diff-Quick-stained thin blood smears [17]. A number of PCR assays have now been described for detecting *Plasmodium* and *Haemoproteus* from blood samples. However, coamplification of *Leucocytozoon* spp. occurs in several protocols and this leads not only to scoring of false positive but, in cases of mixed *Leucocytozoon/malaria* infections, may also lead to scoring of false negatives [4]. Therefore, microscopic examination of blood smears still remains a valid technique for the diagnosis of blood parasites in birds. Infection with haematozoa may last for years in their avian hosts [1]. Many parasites cause seasonal relapses, often stress-induced or associated with increase of vector availability [17].

Lack of diagnosis or of appropriate treatment leads to long-term persistence of the haematozoa. This is obviously
not without immunological and clinical consequences, whether the parasite is considered benign or pathogenic [19]. Persisting *Babesia* and *Ehrlichia* spp. infection in dogs help as predisposing factor for *Dirofilaria repens* infection and pathogenicity [23]. There is no reason to exclude that this is true also in avian medicine and may justify the overall high incidence of concurrent diseases and agents found associated with blood parasites (60%), particularly with *Babesia* shortti (77%), in the present study, including evidently opportunistic organisms such as *Aspergillus* spp. It has been noted that benign haematozoa manifest some degree of morbidity in cases of dual or multiple infections with disease agents such as helminths, bacteria, viruses and other haematozoa [17]. This observation is in accord with the theory of haematozoa acting as predisposing factors for secondary opportunistic infections suggested in this study.

**Acknowledgements**

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**References**

32. TARELLO W.: Clinical signs and response to primaquine in falcons with *Haemoproteus tinnunculi* infection. *Veterinary Record*, 2007, 161, 204-205.