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# A POSSIBLE RELATIONSHIP BETWEEN BUMBLEFOOT RESPONSIVE TO POTASSIUM ARSENITE AND MICROCOCCI IN THE BLOOD OF THREE BIRDS OF PREY

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Pododermatitis (bumblefoot) is a major health problem of falcons worldwide because healing processes in the talons are difficult and lengthy. A peregrine (*Falco peregrinus*), a merlin (*Falco columbarius*) and a saker falcon (*Falco cherrug*) with bumblefoot at different stages ranging from III to V, were all found to be carriers of micrococcus-like organisms in the blood and two of them were successfully treated with 0.5% potassium arsenite in low dosage given intravenously. A number of considerations are made on the immune dysfunction aspects of bumblefoot in birds of prey and on the emerging role of arsenic-based medicaments in the treatment of animal and human immune dysfunction syndromes.

**Key words:** Bumblefoot, pododermatitis, bird of prey, falcon, micrococci, potassium arsenite, treatment

Pododermatitis (bumblefoot) is an inflammation of the talons in birds of prey and is considered both a serious and frustrating problem (Kiel, 1985; Muller et al., 2000). Clinical signs include abrasion, swelling, ulceration and loss of one or more talons (Cooper, 1985). Cases of bumblefoot may be classified according to their stage of development. Stage I is characterised by superficial lesions, no evidence of infection and favourable prognosis. Stage II appears as a localised infection which affects the superficial structures of the tarsal pad. Stage III is a generalised infection affecting deeper structures. In Stage IV, the deeper structures of the foot are seriously affected and damaged, whilst in Stage V the bone is infected, prognosis is poor, and euthanasia is recommended (Forbes, 1997). The condition is claimed to be the result of anatomical, traumatic and dietary factors, including improper perching, poor hygiene, piercing of the bottom of the feet and leg fractures (Rodriguez-Lainz et al., 1997). Nonetheless, these features alone are not sufficient to explain all the damages observed, and the aetiopathology of the condition still remains uncertain (Forbes, 1997). Treatment is difficult

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and frustrating and relapses are frequent (Cooper, 1985). Dietary therapy, protracted courses of antibiotics and surgical methods involving sharp excision, débridement, skin transplantation and finger amputation have been suggested to prevent recurrences (Harcourt-Brown, 1999).

Bacteria such as *Escherichia coli* and *Staphylococcus* spp. have been isolated from the affected tissues (Coles, 1985). However, long-standing therapies with specific antibiotics, even if based on bacterial cultures and sensitivity tests, are rarely efficacious in resolving the pathology and/or preventing the relapses (Coles, 1985; Cooper, 1985). The three cases described here appear to confirm such observations and to provide further information on the clinical management of bumblefoot.

## Clinical cases

*Bird #1*

An adult male peregrine falcon (*Falco peregrinus*) bearing two rings (FO55WAA and 2906A680), which demonstrate that it was a captive-bred falcon, was found near Perugia (Italy) on 6 May 1997. The bird was unable to move, evidencing wing paralysis, anaemia (PCV = 25%), poor feather condition, lameness and bumblefoot at stage III, approximately 2 cm in width, on the right foot.

X-ray examination showed a recent fracture of the right tibiotarsal bone and faecal examination proved negative. Some of the symptoms observed seemed to suggest an underlying immune dysfunction syndrome (Tarello, 2001*c*). Consequently a thorough search for haemoparasites was decided before submitting the falcon to surgery with intramedullary pinning of the tibiotarsal bone, which was eventually carried out later on. Blood samples for smear preparation were taken from the brachial vein after a few feathers had been plucked and the area dampened with alcohol in order to provide complete asepsis of the site, while the bird was cast on its back.

Microscopic examination of two blood smears stained with the Wright technique (× 100, Leitz Biomed) revealed the unusual presence of micrococcus-like organisms, sized 0.3–0.5 μm, scattered on the external surfaces of 15% of red blood cells (RBCs) (Figs 1 and 2). These organisms were identical in colour, shape and size to those previously observed in eight birds of prey affected by Chronic Fatigue and Immune Dysfunction Syndrome (CFIDS), and no other typical avian blood parasites were noticed (Tarello, 2001*b*).

The symptoms and blood anomalies observed led to a diagnosis of CFIDS associated with bumblefoot stage III and, on the basis of previous experience (Tarello, 2001*e*), to a treatment with potassium arsenite 0.5%, given in the brachial vein at low dosage (0.05 ml/Kg/day) for four consecutive days. No other medical or dietary treatment was performed and the bird was fed as usual with quails and kept in a small aviary. On day 4, the peregrine falcon was more reac-

tive and lively and its appetite and weight were improving. At the same time, the bumblefoot area had significantly decreased from 2 cm to 1.5–1.7 cm, and direct inspection revealed an evident reduction of inflammation and swelling, along with mild signs of healing and a white exudative serous discharge. In consideration of the unexpected improvement of bumblefoot and of the decreased number of micrococci visible in control blood films made on day 4 (10–12% of RBCs affected), it was decided to give further three injections of potassium arsenite 0.5%, once a week at the same dosage. No adverse effects were observed and the clinical response progressed into further improvement. Two weeks later, on the day of the fifth injection, the progressive improvement of the general condition (the bird was now able to fly) was associated with further cicatrisation, complete disappearance of swelling and crusting and a considerable reduction of the bumblefoot area (from 1.5–1.7 to 0.8–1 cm). Seven days later (24th day), at the time of the sixth injection, only one small lesion of around 0.5 cm in diameter could be detected. On the day of the seventh injection (31st day) the bumblefoot could be considered cured. It is remarkable that the erosions healed without the need of any topical aid.

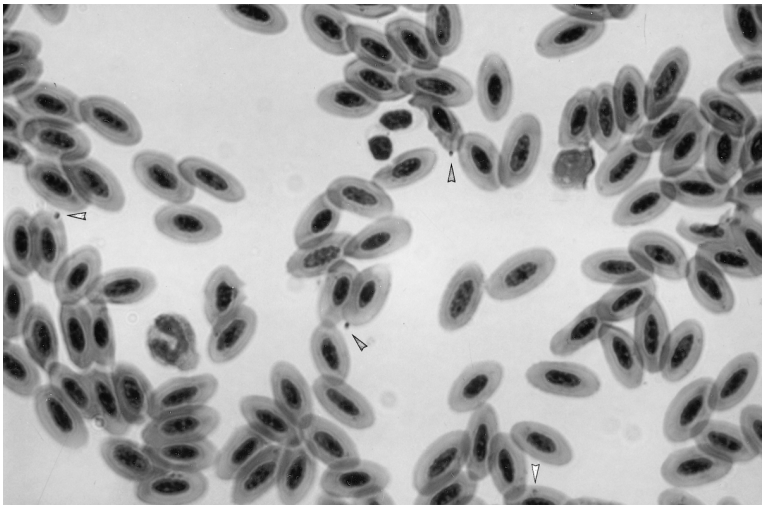

*Fig. 1.* Blood smear from a bird of prey (merlin) suffering from bumblefoot. Micrococcus-like organisms, 0.3–0.5 μm in size, are revealed adhering to the external surface of some red blood cells (× 100)

The haematological control examination performed two weeks later was negative for micrococci, and the anaemia had disappeared (PCV = 41%). During the following 12 months the peregrine falcon did not suffer from relapses, nor did it receive any other medical or surgical treatment. Considered imprinted to humans, the bird was not released in the wild and was kept in an aviary at the L.I.P.U. headquarters of Parma (Italy).

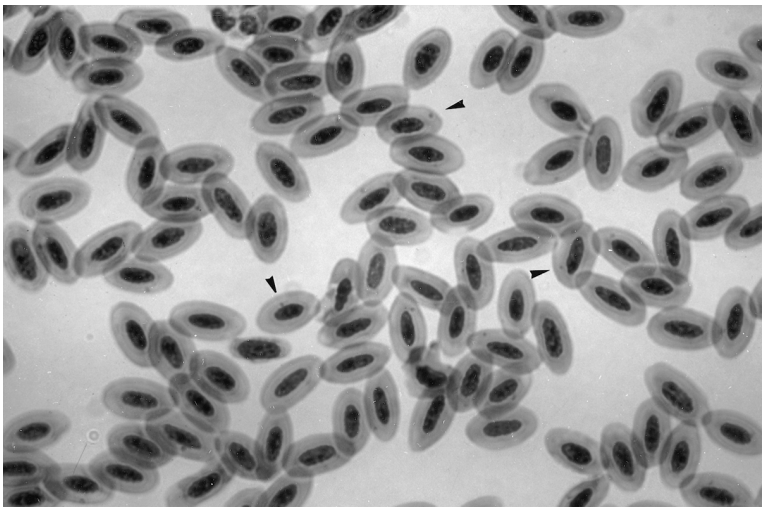

*Fig. 2.* Bird of prey (merlin) with bumblefoot. Micrococcus-like organisms can be observed on the external surface of some red blood cells (× 100)

*Bird #2*

A captive-bred young adult female merlin (*Falco columbarius*) weighing 215 grams was visited in Sharjah (United Arab Emirates) during May 2001. It was affected by bilateral bumblefoot stage III, 0.7–0.8 mm in size, associated with periodic fever and weakness, which had been previously and unsuccessfully treated with several antibiotics (amoxycillin + clavulanic acid, lincomycin and enrofloxacin), anthelmintics (fenbendazole), vitamin A and multimineral formulation.

X-ray, complete blood cell count (CBC) and faecal examinations showed no abnormalities. Microscopic examination (×100) of two fresh blood smears stained by the Wright technique revealed the presence of micrococcus-like organisms on 22–25% of RBCs and the absence of other avian haemoparasites. Following previous therapeutic experience, potassium arsenite 0.5% was given intravenously at dosage of 0.05 ml/Kg/day (diluted 1/10) for 3 days to this raptor. As expected, within a few days the bumblefoot showed bilaterally marked signs of healing, including rapid reduction of size and swelling, increased number of capillary vessels around the lesion, cicatrisation with crusting and mild sero-haemorrhagic discharge. On day 10, the bird's reaction to the treatment resulted in better movement and vivacity, increased appetite and weight gain (235 grams). The examination of fresh blood smears showed a reduced number of RBCs (10–12%) parasitised by micrococcus-like organisms and a fourth injection of potassium arsenite 0.5% was given in the brachial vein at the usual dosage (0.05 ml/Kg, diluted 1/10). The clinical response appeared satisfactory

because one week later, on day 17, the bumblefoot had completely disappeared, although 2–3% of RBCs were still carrying micrococci on their external surfaces, leading to a fifth injection of potassium arsenite 0.5%.

On day 31, the bird was healthy and highly reactive to handling. Fresh blood smears proved negative for micrococci. Both tarsal pads were now protected by a thick layer of dry hard skin and bumblefoot did not recur during the subsequent two months.

*Bird #3*

In June 2001, an adult female saker falcon (*Falco cherrug*) weighing 1060 grams, with chronic bilateral pododermatitis (bumblefoot) stages IV–V was presented to the author in Dubai (United Arab Emirates). The symptoms first developed in December 2000, 15 days after the arrival of the bird from the USA, and in the owner's opinion the stress due to the long journey was probably responsible for the initial appearance of lesions.

Previous medical and surgical treatments included long-standing courses of antibiotics, aspecific immunostimulation and amputation of two fingers for skin transplantation to the site of bumblefoot, which did not produce any kind of benefit. Laboratory testing for haemoparasites revealed the absence of members of *Haemoproteus, Leucocytozoon, Plasmodium and Trypanosoma* spp. and the presence of micrococci on 10–12% of RBCs. According to previous experience a treatment with potassium arsenite 0.5% was suggested as a secondary choice and also as a promising therapy for bumblefoot. However, the owner denied consent to such a treatment on the belief that arsenical drugs are 'dangerous' and 'carcinogenic'.

## Discussion

This paper describes in detail three avian cases of pododermatitis (bumblefoot), all associated with the presence of micrococci in the blood.

Case #1 (peregrine falcon) and #2 (merlin), both with bumblefoot at stage III, found complete cure and concurrent disappearance of micrococci from the blood, after a treatment with potassium arsenite 0.5% in low dosage (0.05 ml/Kg/day) given intravenously.

A clinical check performed one year later in the peregrine and 2 months later in the merlin, confirmed lasting remission, without subsequent relapses. These results are remarkable, since the condition is considered at risk of recurrence when treated with traditional methods (Forbes, 1997). Cases of bumblefoot stage III, characterised by generalised infection affecting structures deeper than the skin, are believed to inevitably require surgery, following bacterial sensitivity testing and antibiotic treatment (Coles, 1985; Forbes, 1997). Furthermore, case

#2 had already been previously treated with several antimicrobial and anthelmintic medicaments without success.

To the author's knowledge, this is apparently the first report on the efficacy of potassium arsenite 0.5% (Fowler's solution 1/2) in two cases of pododermatitis (bumblefoot) in birds of prey.

The constant observation of micrococci 0.2–0.3 μm in size on the external surface of the erythrocytes in all three cases of the present study is not in contrast with the well-established link between chronic *Staphylococcus* infection and bumblefoot in raptors (Coles, 1985; Cooper, 1985). This bacterial presence in the blood has already been described in eight birds of prey affected by CFIDS, in association with *Staphylococcus*-positive blood cultures and high muscular enzyme levels (creatine kinase), typical of a neuromuscular disorder, responsive to an arsenical medicament (Tarello, 2001*c*). It is interesting to note that myopathy has already been found to be closely associated with pododermatitis incidence in broilers (Wight and Siller, 1980). Recently, intradermal footpad injection with *S. aureus* resulted in local swelling and systemic infiltration of bacteria into spleen, liver and blood in broilers, not in contrast with the results reported here (Zhu et al., 2001).

The owner of bird #3 denied consent to the administration of a low-dosage potassium arsenite 0.5% course, because arsenic is often considered as a synonym of 'poison' and 'cancer'. Interestingly enough, arsenic is probably the oldest known chemical agent used for treating cancer (Uthus, 1994) and ulcers (Hippocrates, 400 B. C.). Hippocrates used arsenic sulphide diluted with oil of juniper as a remedy for ulcers and other skin diseases. In the recent past the efficacy of arsenic against various dermatological illnesses was acknowledged in both human (The Merck Index, 1974) and veterinary medicine (Hutÿra et al., 1949). Furthermore, arsenic is an essential element to some species, including humans (Anke, 1986; Emsley, 1991), although the specific biochemical reason for its importance has not yet been determined (Uthus, 1994).

The therapeutic effects of some arsenical compounds are today rediscovered and used against a variety of cancers (Soignet et al., 1999) and Chronic Fatigue Syndromes in both humans and animals (Tarello, 2001*c–h*) in association with micrococci in the blood and skin problems such as pyoderma, acne and abscess in the hooves in horses (Tarello, 2001*a, h*). These ailments are strictly associated with *Staphylococcus* spp. infection in mammals (Ruffo, 1995), as is bumblefoot in birds of prey (Coles, 1985; Cooper, 1985). Since this defect is more immunological than anatomical in nature, sharp surgical excision, skin transplantation and finger amputation are likely to be unsuccessful, with ensuing poor prognosis of the condition, as proven by the recurrence observed in Case #3 described here. A thorough search for underlying causes of immunodeficiency (with consequent chemotherapy) is suggested today as the proper answer to the problem (Forbes, 1997; Muller et al., 2000). According to these guidelines, in all cases described in the present study an accurate search for haemoparasites by direct microscopic observation of

fresh blood smears led to the detection of micrococci on the external surfaces of 10–25% of erythrocytes and to the exclusion of *Plasmodium, Haemoproteus, Leucocytozoon* (Hawkey and Dennett, 1989) and *Aegyptianella* spp. (Tarello, 2001*b*).

This preliminary report does not intend to establish a direct cause/effect connection between bacteriaemia due to micrococci, as a primary and/or unique cause, and bumblefoot in birds of prey. However, in Cases #1 and #2 micrococci in the blood were certainly an existing co-factor for the severity and duration of the illness, because following treatment with potassium arsenite 0.5% clinical improvement and recovery were rapid and satisfactory and bacteria in the bloodstream could no longer be observed in the control carried out two weeks after the end of the therapy.

This was apparently the main difference noticed between the blood smear examinations of the same birds, either when affected with bumblefoot and when clinically cured, as previously observed in birds of prey with CFIDS (Tarello, 2001*c*).

Although no blood culture was performed and Gram-stained smears were not examined, the micrococcus-like organisms observed in these three raptors were similar in shape, size and colour to those previously observed in birds of prey, dogs and cats affected by CFS, in which several blood cultures proved also positive for *Staphylococcus intermedius*, *S. xylosus, S. epidermidis, S. lugdunensis, S. cohnii* and *S. chromogenes* (Tarello, 2001*c, d, f*).

Pododermatitis associated with micrococci in the blood, recovery of *Staphylococcus xylosus* multiple antibiotic-resistant strain and response to an arsenical medicament (thiacetarsamide sodium) in low dosage, has already been described in dogs (Tarello, 2000).

Stress, lack of exercise, wounds, diet and anatomical peculiarities (Muller et al., 2000) predispose the captive-bred falcons to bumblefoot: these factors cannot be modified to the extent of preventing the condition (Harcourt-Brown, 1999). On the contrary, immune dysfunctions involving infectious agents that can be medically treated, must be considered with attention in the clinical practice, with an eye on non-invasive treatment with a better prognosis. The data collected in three avian cases seem to indicate that representative members of *Staphylococcus* spp. are likely to be infectious agents that favour bumblefoot with persistent bloodstream infection and that potassium arsenite 0.5% may be a promising effective therapeutic agent for the condition. Further studies are required for a more in-depth investigation of these aspects in veterinary avian pathology.

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