

Pododermatitis (Bumblefoot): Diagnosis, Treatment, and Resolution

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In: Reviews in Veterinary Medicine by Revah I.

Updated: FEB 20, 2021

Languages: EN

Introduction - What is Bumblefoot?

Pododermatitis, commonly known as “bumblefoot,” has become a frequently seen disease in companion and aviary birds. Pododermatitis is a general term for any inflammatory or degenerative condition of the avian foot. Often, birds will come into the clinician’s office for a routine annual examination, and the feet will show signs of subclinical or even more serious disease. The condition may range from very mild redness or swelling to chronic, deep-seated abscesses and bone destruction. If caught early, the underlying, predisposing factors may be corrected, and the disease will often be reversed.

Pododermatitis has been reported in many species of birds, but on a clinical level, it is particularly problematic in captive birds of prey, Galliformes (*chickens and turkeys*), Anseriformes (*ducks, geese, and swans*), waders, penguins, and many Psittaciformes (*parrots*). Of the psittacines, Amazons, budgerigars and cockatiels are particularly vulnerable to this disease. The condition is frequently described in raptors, but it may occur in any avian species, including canaries and finches [1]. Because footpads are present in psittacines more so than in other species, birds in the parrot family are more likely to suffer from this disease [2].



Figure 1. Pododermatitis at Stage 3 on the feet of a finch, side view (image courtesy Tamara Lowes; used with permission).



Figure 2. Pododermatitis at Stage 3 on the feet of a finch, plantar surface (image courtesy of Tamara Lowes; used with permission).



Figure 3. Extremely long nails cause the bird to stand in an unnatural position, leading to pododermatitis (image courtesy of Leila Marcucci, Bay Area Bird Hospital; used with permission).

The scales on the feet are composed of highly keratinized epidermal (*the outermost layer of skin*) tissue, and this tissue covers the lower leg (*podotheca*) and foot. The nails/claws are formed by plates of strong, keratinized tissue that enclose the terminal phalanx (*last toe bone*) of each digit. It is this keratinized tissue on the plantar (*bottom*) surface of the feet that gets quickly worn away when the foot becomes irritated and sore [2].

Birds most at risk for developing pododermatitis are obese birds having excess pressure placed on the feet, aged and disabled birds, birds with limited mobility, chronically ill birds, and those with any kind of immune system weakness [3].

1. Causes or Predisposing Factors Behind the Development of Bumblefoot

- Obesity and inactivity
- Improperly designed perches: perches that are too small or have no variety of diameter; those that are hard or uneven; dowel or hardwood surfaces; any rough-textured perches such as warming perches, plastic perches, those covered in sandpaper, concrete, or burlap; and perches or spirals made of sisal
- Hard, coarse floor surfaces, such as cement
- Poor nutrition and vitamin A deficiency
- Poor husbandry: damp, unsanitary bedding and all substrates; an accumulation of feces, and overall unsanitary environment
- Fighting among flock members
- Overgrown toenails
- Previous leg or foot injury leading to crippling
- Frostbite injuries and thermal burns
- Leg or conformation abnormalities
- Cracks or worn-away areas and discoloration of the skin
- Stress, hypothyroidism [3], and hepatic (liver) dysfunction [4]
- Severe poxvirus lesions with secondary bacterial infections
- Damage to the plantar surface of the foot. Injuries cause lesions to develop on the plantar surface of the phalanges or on the tarsometatarsus. Plantar decubital ulcers (*pressure sores*) are common [5].

1.1 Perches that are Harmful to Birds' Feet and Leg Joints

These perches are known to be detrimental to the plantar surface of the feet and cause arthritis in the leg joints. Any of these can be wrapped with Vetrap™ or cohesive tape/bandage wrap to vary the diameter of the surface; however, most are round and need to be wrapped with high and low placement of the cushioned wrap.



Figure 4. Plastic perches. These are usually too small for the bird, they cause the bird to grip hard to stay balanced, and they create pressure sores (from Trixie Natural Living Perches).



Figure 5. Rough-textured perches. These include cement, sandpaper or warming perches; they irritate the plantar surface of the foot, cause sores and arthritis and do nothing to keep nails short (image courtesy of K&H Pet Products Bird Thermo-Perch).



Figure 6. Sanded perch covers for dowel perches. Not only do they not keep the nails filed, but they also cause sores on the feet and arthritis in the legs. The owner can remove the sandpaper covers and wrap the perch with cohesive wrap, making sure to vary the diameter of the wrapped surface. They also have a tendency to slip on the perch, causing the bird to grip tightly, leading to arthritis (image courtesy Penn Plax Sanded Perch Covers for Small Birds).



Figure 7. Rough-textured perches. They do nothing to keep the nails filed; they just irritate the plantar surface, causing sores and arthritis in the feet and joints of the legs (image courtesy of Kathson Bird Perch Parrot Stand Cage Accessories Natural Wooden Stick Paw Grinding Rough-surfaced).



Figure 8. Round dowel perches. These will place all the bird's weight in the same place and are difficult for the bird to grip, forcing him to grip tighter all the time. Any perch that can become slippery puts additional strain on the muscles of the leg and foot to stay balanced (image courtesy Prevue Pet Products Birdie Basics Wood Perch 10 in).

1.2 Perches that are Beneficial for the Birds' Feet and Legs



Figure 9. Booda rope perches. These come in various diameters and lengths and also in spirals. They give the feet the soft, comfortable perching they need when they are on their feet all the time and have minimal flying time. The owner needs to watch for chewing of the cotton fibers and possible ingestion which may lead to crop impaction (image courtesy of JW Comfy Perches for Birds).



Figure 10. Hardwood perches, such as this manzanita perch, offer variety of diameters. Even these can be slippery, causing the bird to grip hard. They can be wrapped with cohesive tape (image courtesy of Northern Parrots).



Figure 11. Platform perches. These come in a variety of sizes, shapes and composition. They can be found in wood, chrome, and coated wire. They should be covered with soft, padded material, such as flannel, fleece, or a stack of paper towels for comfort (image from Pevor Wooden Parrot Bird Cage Perches in Amazon).

2. Symptoms of Bumblefoot in Birds

- Dark, circular scabs on feet

- Redness, shininess, and small, red sores on the plantar surface of the foot
- Abrasions, cuts, tissue damage on the bottom of the foot
- Swelling and thickening of the skin
- Lameness and swollen joints in the feet or toes
- Reluctance to walk, stand, or grasp normally with one or both feet
- Ulcers on the soles of the feet [6, 3]



Figure 12. Healthy tissue in a cockatiel (image by J. Miesle).

3. Means of Infection

There are two ways infection can set it:

- Through a puncture in the skin of the base of the foot (a talon, a thorn, or foreign object)
- Pressure sores (decubitus ulcers) on the bottom of the foot [7].

3.1 Punctures to the Skin Leading to Bacterial Infections

Infections may occur when penetrations, such as cuts and sores, happen. Bacteria such as *Staphylococcus aureus* may enter the skin and cause damage if it has not been observed and treated [2]. Once the wound becomes serious, oral antibiotics, anti-inflammatories, and topical antibiotics will be needed [6].

Systemic infections that result in decubital lesions or death can occur secondary to bumblefoot and are caused by virulent strains of *S. aureus*. *S. aureus* is frequently isolated from the lesions, but the birds will usually not respond to antibiotic therapy alone. These bacterial lesions may quickly lead to digital necrosis and gangrenous dermatitis. *Staphylococci* are by no means the only bacteria that might be recovered from diseased tissue: *E. coli*, *Corynebacterium* species, *Pseudomonas* species, and yeast are frequently cultured from the lesions [8].

3.2 Decubitus Ulcers (Pressure Sores)

Decubital ulcers are open sores on the skin, often on the skin covering bony structures. Pressure sores occur because of uneven weight-bearing that leads to damage and devitalization of the skin. Both of these lead to bacterial and/or fungal infections of the skin. Once the process begins, a series of changes is initiated which will eventually damage the tendons of the foot and spread to muscles, joints, and other tissues. It can become a chronic disease, affecting the aortic and mitral valves of the heart and causing endocarditis (*inflammation of the heart valves*) and vascular insufficiency (*poor blood flow*), lethargy and dyspnea (*labored breathing*) [7].

4. Additional Contributing Factors in the Development of Pododermatitis

4.1 Malnutrition

In Psittaciformes and Passeriformes (songbirds), most lesions are believed to be the result of malnutrition; poor nutrition causes the skin of the foot to become dry, flaky, and hyperkeratotic (developing a thick, outer layer of keratin on the skin). It is thought that dry, hyperkeratotic skin on the feet changes the mechanics of weight-bearing on the metatarsal pads. This condition is also precipitated by environmental deficiencies and systemic disease [1].

Sunflower seeds have a high-fat content. Too many in the diet can lead to obesity in parrots and other pet birds. Traditionally, parrot diets have consisted of a mixture of seeds, with sunflower seeds being an important part of most diets (50% of the content of a sunflower seed is fat). Over the last decade, there has been an increase in the number of parrot owners that feed their pets commercial pellets; but this is also not a perfect alternative. Pelleted food contains more fat and protein than the amount most parrots need, and the oils added to the pellets (sometimes palm and coconut oils) may predispose birds to atherosclerosis (fat deposits in arteries). The heavier the bird, the more weight and pressure it puts on its feet, resulting in the development of pododermatitis. This is aggravated by lack of flying; birds do not put pressure on their feet while they fly, so birds that do not fly are more predisposed to pododermatitis and obesity [9].

4.2 Vitamin A Deficiency

Some forms of pododermatitis are caused or exacerbated by Vitamin A deficiency. Birds that eat only seeds are susceptible to it since seeds are typically low in Vitamin A. This vitamin promotes appetite and digestion and also increases resistance to infection and to some parasites. The most obvious sign of a Vitamin A deficiency is a feather stain above the cere (the fleshy area which contains the nares or nostrils). The staining of the feathers above the cere reflects a discharge from the nostrils. Subtle differences may be seen as far as the color intensity of the cere and feathers and the overall condition of the plumage are concerned. A bird deficient in this vitamin may have pale, rough-looking feathers that lackluster. The cere may look rough instead of smooth, and you may see an accumulation of a yellow, dry scaling on the sides of the beak [6].

Vitamin A deficiency weakens the epithelium (the thin, top layer of skin) of affected birds. Pressure sores, pressure ulcers, or decubitus ulcers occur when the bird is in the same position for a long period of time; the result is uneven weight-bearing. The ulcers are localized injuries to the skin and/or underlying tissues that usually blood flow to the soft tissue. The constant friction from the wrong types of perches can pull on blood vessels that feed the skin. Decubital ulceration on the plantar surface of the feet is common in older, obese, nutritionally deficient psittacines [5].

4.3 Limited Flying Opportunities

Restricted flight opportunities lead to inactivity and obesity, and these produce excessive pressure on plantar surfaces, the toe pads, and the tarsometatarsus. Erosion occurs, and ulcers and staphylococcal infections develop [5].



Figure 13: Grade I lesions. Note the shiny area on the footpad. Burgmann PM, Symptoms and treatment of bumblefoot in Parrots (image courtesy of HARI - Hagen Avicultural Research Institute; used with permission).

4.4 Secondary Disease

“Pododermatitis can also take place secondary to infectious or parasitic diseases, penetrating foot wounds, or leg injuries that affect normal gait and weight distribution. Epithelial damage that arises secondary to asymmetric weight-bearing on the metatarsal pad causes reduced circulation, microepithelial (microcysts; very small, round vesicles containing fluid and cellular debris) damage, local impairment of the immune system, and ultimately, invasion of opportunistic pathogens” [10]. For companion birds, raptors, and other wild birds, pathogenic bacteria introduced at traumatized sites may lead to abscessation (formation of abscesses), osteomyelitis (bone infection), or joint changes [7]. (For more information on the treatment of raptors, See Appendix A).

4.5 Arthritis

Septic arthritis may also play a part in the development of pododermatitis. Joints may become infected through a direct, penetrating wound or through the hematogenous route (spread through the bloodstream). Although the infection may be controlled, a decrease in the range of motion of the joint usually occurs [11].



Figure 14: Grade 2 lesions. Burgmann PM, Symptoms and treatment of bumblefoot in Parrots (images courtesy Hagen Avicultural Research Institute; used with permission).



Figure 15: Grade 3 lesions. Burgmann PM, Symptoms and treatment of bumblefoot in Parrots (images courtesy Hagen Avicultural Research Institute; used with permission).

4.6 Contact with Tobacco Products

Many affected birds belong to cigarette smokers. Passive inhalation of cigarette, cigar, pipe smoke, e-cigarettes, marijuana and other types of airborne drugs not only causes ocular and respiratory disease in birds, but it also damages the integument. Marijuana exposure also causes severe depression and regurgitation in birds and should be strictly avoided. Pododermatitis has been observed in birds handled by smokers as the nicotine residues on the hands of smokers will cause this irritation. If minor, the lesions may spontaneously resolve when the client stops smoking or washes his hands before handling the bird [12].

The feet and legs should be uniform in texture and color. The feet should have prominent scale patterns on both the dorsal and plantar surfaces. Changes that result in the smoothing of the plantar foot surface can instigate chronic and severe foot and leg diseases. One of the common etiologies of foot abnormalities is contact with nicotine sulfate from the hands of cigarette smokers. The feet are particularly vulnerable to fungal diseases as a result of smoking toxicity [12].

Pododermatitis has been observed in some birds handled by people who smoke routinely. Repeated exposure to the nicotine residues on the hands of smokers causes this local irritation. Macaws (and other birds with bare cheek patches) may suffer similar dermatitis on their cheek patches following repeated contact with a smoker's hands [12].

When toxic particulates and gases in the air assault a bird's respiratory system, skin, and feathers, feather destruction and plucking result. Heat causes the smoke to rise; then, when it cools, gravity brings it back down. The toxins land on the birds, their perches, their cage bars, toys and food. It is also on the smoker's hands, arms, clothes, and any other exposed skin—even the hair. If the smoker's hands are coated with chemicals from holding the cigarette, it is easily transferred to his bird. In one case, an amazon, who turned out to be very sensitive to chemical exposure, began mutilating his feet. The clinician determined the cause to be his perches which were covered with residue from cigarette smoke [13].



Figure 16. Grade 4 lesions on a cockatiel with arthritis (image courtesy of Julie Burge; used with permission).

4.7 Contact with Strong Cleaners and Disinfectants

These may also be responsible for irritation and dermatitis on the feet. Cleaning liquids should always be dry before the bird walks on the cleaned surface. Cleaning products should be carefully chosen so that chemical irritants are not used [12]. Air freshener plug-ins and sprays should never be used around birds. (They also damage the respiratory system) [13].

4.8 Allergens

The syndrome appears to be more common in the spring, suggesting a seasonal allergy. Seasonal recurrences of the lesions may be prevented by the oral administration of prednisolone about one month prior to the time that lesions typically occur [12].

5. Avian Veterinary Examination

5.1 Visual Exam

A bird's skin is very delicate, and the skin of the foot reflects the condition of the rest of the dermis. The plantar surface of each foot should be checked daily by the owner, and the clinician should inspect the feet at the bird's visits. Both owner and clinician should note the condition of the metatarsal and digital pads and look for loss of definition of the epidermis (seen as a shiny, reddened surface), swelling, erosions, ulcers, and scabs. Birds that are crippled from an injury or genetic defect are prone to developing sores on one or both feet due to the stance they must assume. The owner and practitioner must be observant for signs of pain or discomfort [13].

If a bird is lame on one leg, he must bear his weight on the unaffected leg; this, in turn, can lead to pressure necrosis, infection, and subsequent pododermatitis on that foot as well. The clinician should always examine the other leg and foot closely when any lameness occurs. A complete examination, including radiographs, may require that the bird be anesthetized to reduce stress on it [13].



Figure 17. Grade 4 lesions (Photo from <http://www.officialbarrieshuttbudgerigars.com/>).



Figure 18. Grade 5 pododermatitis in parakeet Grade 3 lesions. Burgmann PM, Symptoms and treatment of bumblefoot in Parrots (images courtesy Hagen Avicultural Research Institute; used with permission).



Figure 19. Grade 5-6 pododermatitis in a cockatiel. Obesity in Parrots (image courtesy David Perpiñán; used with permission).

5.2 Testing

Bacterial samples will be taken and evaluated at a microbiology lab in order to isolate the offending organism. An antibiotic sensitivity test may help determine the best course of antibiotic treatment to rid the bird of this condition or to manage it in the case of a chronic issue. A blood sample will be taken to check for other possible health conditions. X-rays will reveal signs of infection and will indicate any areas on the joints or bones where there's been erosion or other damage [3].

6. Clinical Grades of Pododermatitis

Hagen Avicultural Resource Institute definitions: The following classification grades have been lifted directly from the HARI institute website. (All are used with permission from HARI).

A classification scheme grading from early clinical signs and progressing to severe lesions has been established. The clinical progression of the disease varies based on the species and the factors that contributed to the infection.

Clinical Grades of Pododermatitis [4]

Grade I: Desquamation (*shedding of the epithelial or skin tissue*) of small areas of the plantar foot surfaces is represented clinically by the appearance of small, shiny pink areas and peeling or flaking of the skin on the legs and feet. Initial lesions are recognized as hyperemia (excessive amount of blood). Flattening of the skin of the digital and metatarsal pads is visible. These are the sites of maximum weight-bearing. (*Thinning of the plantar surface of the foot with some reddening*).

Grade II: These lesions progress if untreated, and bacteria invade the subcutis, resulting in a scab and mild swelling. (*The subcutis is the deeper layer of the dermis, containing mostly fat and connective tissue*). Smooth, thinly surfaced, circumscribed areas appear on the plantar metatarsal pads of one or both feet with the subcutaneous tissue almost visible through the translucent skin. No distinct ulcers are recognized. (*The thinning of the plantar surface of the foot has progressed to the point that subcutaneous tissue such as tendons can be seen through the skin*).

Grade III: The sores progress to form a caseous (*having a cheese-like texture*) abscess with marked swelling and pain. Ulceration of the plantar metatarsal pads occurs, and in some birds, a peripheral callus may form. Ulcers form on the soles of feet with callouses forming around the edges of the lesions. Some pain and mild lameness are present.

Grade IV: Infection of the tendon sheaths develops. Corresponding cellulitis tracks toward the intertarsal joint and the digits along with flexor tendon rupture. There is a necrotic plug of tissue present in the ulcer. Most species with ulcers and accumulation of necrotic debris exhibit pain and mild lameness. (*Necrosis refers to cell death; the tissue turns black*).

Grade V: Swelling and edema (*cellulitis*) of the tissues surround the necrotic debris. The digits of the foot may also be edematous (*holding fluid*). Necrotic debris starts to accumulate in the metatarsal area, indicating infection of the tendon sheaths. Severe lameness is common, and the entire metatarsal pad may be affected. This is generally a chronic lesion leading to osteoarthritis and septic arthritis of the tarsometatarsal-phalangeal joints. Cellulitis surrounds the area of necrosis, and the foot can be swollen with fluid. Tendon and metatarsal pads become infected; pain and severe lameness are present.

Grade VI: Necrotic tendons are recognized clinically as the digits swell and the flexor tendons rupture. Ankylosis and nonfunctioning digits usually present in recovery. (*Ankylosis refers to the stiffness of a joint due to abnormal adhesion and rigidity of the bones of the joint, which is usually the result of injury or disease*). (The digits are swollen and the necrotic flexor tendons on the plantar surface of the foot rupture. Even with treatment, non-functioning digits and joint fusion will be present).

Grade VII: Osteomyelitis develops. This is a bacterial bone infection leading to the destruction of the bone itself. (*Bone infection can progress to systemic infection and death*).



Figure 20: Comparison of a healthy plantar surface on the right and Grade VII severe case of pododermatitis on the left (image courtesy Lauren Thielen; used with permission).

6.1 Grading Discussion

Grades I to III lesions are common in Psittaciformes and Passeriformes that are on all-seed or over-supplemented fruit and vegetable diets, are overweight, have no exposure to sunlight, or are kept on improper perches. With proper husbandry and nutrition, most cases recover with little medical intervention. The type of substrate and the size, shape and covering material of the perches may all influence the bird's weight distribution on the toes and metatarsal pads. These affect the amount of skin wear on the plantar surface. For example, a perch that is too wide and flat may cause excessive weight-bearing on the toe pads, while one that is too small may cause excessive weight-bearing on the metatarsal pads [4].

Early stages of pododermatitis show loss of the scale pattern on the foot, redness, and mild swelling. This damage can often be treated with topical softeners, improvement of the diet, and modification of the bird's environment. Reversal is possible when the disease is at Grades I and II. The earlier the disease is caught, the more effective the treatment will be. The prognosis for the full recovery of lesions of Grade I to IV is usually more favorable than Grades V to VII lesions [4].

Grade III bumblefoot is common in older, inactive birds that are fed inadequate diets. Early lesions (smoothing of the plantar foot surface) and hyperemia (an excess of blood in the vessels supplying an organ or other part of the body [20]) are frequently missed, and the birds are often not seen by the clinician until this stage. Some birds are not presented until they exhibit a non-weight-bearing lameness. This disease is dynamic and may move from one grade to the next quickly [4].

Damage to the feet in Grades IV to VII usually requires surgical intervention since the changes that lead to infection also reduce the ability of antibiotics to be effective. Debridement of the wound, surgical removal of damaged tissues, and wound bandaging are treatments that are frequently used [4].

Older budgerigars and cockatiels (5-10 years old) may have Grade V or VI lesions if precipitating factors are not corrected early. Bone changes and osteomyelitis may be present. Later stages are very serious and life-threatening. Since the development of antibiotic-impregnated beads, veterinarians can treat later stages more successfully than they could before. Amputation is sometimes necessary. Prosthetics may be used for birds such as ducks that cannot survive with only one good foot [4].

7. Treatment

7.1 Treatment for Early-Onset Pododermatitis, Grades I-III

Grade I to III lesions generally respond to keeping the foot clean and correcting underlying management or nutritional deficiencies. With waterfowl, this frequently involves changing the dimension, shape, and surface of the enclosure and adding adequate swimming areas [5].

Less severe cases may be treated with a combination of environmental and medical methods. Correction of the underlying predisposing factors will often reverse this disease process. Change in diet, frequent exposure to sunlight, improved cleanliness, environmental changes, and the application of a topical antibiotic or antimicrobial cream containing steroids often resolve the problem. These should be used with caution to prevent toxicity. Many topical products are available, such as softening agents for dry, scaly feet, topical antibacterial creams for acute inflammation and swelling, and ointments for granulating wounds (the author has had success using gentamicin sulfate ointment and cream; the ointment worked better than the cream. Massage in a small amount to the tissue morning and evening). Granulation tissue is composed of new connective tissue and microscopic blood vessels that form on the surfaces of a wound during the healing process [5,20].

For all levels of disease, the owner must be willing to continue with the treatment at home. He needs to be made aware that some individuals are highly susceptible to recurrences. If the bird does not respond to these changes, or the condition continues to deteriorate, more complex medical treatment will be necessary [5].

7.2 Goals for Treatment of Advanced Pododermatitis, Grades IV To VII

Advanced bumblefoot is a necrotizing abscess on the plantar surface of the foot. Depending on the location and chronicity of the abscess, the infection may or may not extend to neighboring joints, tendon sheaths and bones [14].

The goals of advanced bumblefoot treatment are:

- To reduce infection, inflammation and swelling
- To establish drainage as needed
- To begin antibacterial topical and oral therapy to eliminate underlying pathogens
- To manage the wounds in order to promote rapid healing
- To initiate surgical intervention when needed
- To ensure an adequate diet, and
- To address environmental deficiencies [13].



Figure 21. Grade VI Pododermatitis in a four-year-old budgerigar with a straight perch in his cage for years (image courtesy of K. Gerbaga Özsemir [14]).

7.3 Treatment Recommendations Based on the Findings of the Clinician

- Correcting any perching and bedding issues
- Adjusting nutrition as needed
- Correcting potential husbandry issues; cleaning and disinfecting the bird's enclosure in order to eliminate injuries and stresses associated with those
- Correcting the bird's diet when it is found to be lacking sufficient vitamin A
- Supplementing the diet to increase vitamin A
- Addressing bacterial infections, whether localized in the wound area or systemic. Cephalexin

antibiotics have been used successfully in cases that involve infection that has spread through the body.

- Increasing the exercise and adjusting the diet of obese birds.
- Treating and dressing any wounds or ulcerations that are present to encourage healing
- Using surgical treatments, natural healing products, therapeutic laser, and even acupuncture as needed. These are determined by the extent to which the pododermatitis has progressed [3].

7.4 Preparation for Treatment

To prepare the lesions for the topical antibiotics, they need to be thoroughly cleaned. One recommendation involves soaking the affected foot in a shallow dish filled with warm water with Epsom Salts added to it. The recommended strength is about one teaspoon of Epsom Salts mixed in with one gallon of clean, warm drinking water. The Epsom Salts will draw out any toxins. Soaking the foot or feet will soften and remove any scab, which allows the lesion to drain any pus and debris. Finally, flush the cavity with hydrogen peroxide to clean the wound out and destroy any bacteria [6]. (*Hydrogen peroxide should be diluted at a 1:10 ratio with water*).

7.5 Dressings and Bandaging

The severity, type, and path of infection will direct treatment. No matter what, the owner should keep the bird's feet sanitized and tailor the living environment to both promote healing and to eliminate destructive perches and surfaces (Rope perches or perches wrapped with cohesive bandaging are the best way to provide soft surfaces) [3]. Oral antibiotics and antibiotic ointments will control the infection. Bandaging may be recommended in order to reduce the opportunity for pathogens to enter the wounds. In more severe cases, surgery (including debridement of abscesses) will help to save the feet, and life, of the bird. Antibiotics will be essential in resolving infection, and the bird can be kept comfortable with pain and anti-inflammatory medication (*Celecoxib is best for birds*) [3].

Medical therapies include the application of topical agents in order to toughen the plantar skin of the foot. Softening agents are also helpful in cases in which the epithelium has become thin. Antimicrobial and anti-inflammatory creams and ointments and hypertonic footbaths provide infection and inflammation control. (*Hypertonic refers to a solution with higher osmotic pressure than another solution. If a cell is placed in a hypertonic solution, water will leave the cell, and the cell will shrink [Merriam-Webster]*) [4].

Once the wound is clean, apply liberal amounts of an antibiotic ointment as prescribed by the veterinarian, and then carefully wrap the foot or feet with gauze; this will keep the cavity clean and the ointment in place and prevent the bird from chewing on it. If the pododermatitis is in the very severe category, a ball bandage may need to adhere to the foot. The lesion needs to be cleaned and ointments reapplied twice a day until the feet appear healthy [6].



Figure 22. A ball bandage is one option for management of a closed toe fracture (image courtesy of Dr. Ariana Finkelstein, Lafebervet).

In severe cases, a hydroactive dressing may be used (*hydroactive: the act or process of combining or treating with water: As the introduction of additional fluid into the body, hydration sometimes helps to reduce the concentration of toxic substances in the tissues dressing and can be used to facilitate healing of the wounds [Merriam –Webster]*). Hydrophilic dressings mix easily with water. Moisture-vapor permeable dressings or hydrocolloid (*a substance that forms a gel when mixed with water*) dressings should be applied topically to enhance wound healing for open, granulating wounds or post-operative incisions. Applying a topical antibiotic and bandaging the feet with sufficient padding to reduce and better distribute pressure on the plantar surfaces is required in many cases. The types of bandaging methods may include simple toe bandages, interdigitating bandages, and ball bandages. Bandaging of affected tissues may go on for several months until the bird responds to the new diet and environmental deficits have been corrected [4].

Initially, the bandage may require daily changing. The frequency of bandage changes can be reduced as the wound becomes less exudative (*producing fluid, especially in inflammation*). Once granulation tissue forms at the edge of the ulcers, scabs should be removed by the clinician, and the lesions should be kept clean to facilitate healing [4].



Figure 23: Grade VII bacterial pododermatitis. This lesion usually develops following pressure necrosis with a subsequent bacterial infection (image from Lightfoot and Schmidt [5]).

7.6 Additional Therapy for Grade IV to VII Lesions

This includes:

- Cleansing and treating the wounds daily with multimodal medications and changing the

bandages daily

- Treating the wounds locally by using the antibiotic-impregnated matrix; antibiotic-impregnated beads are implanted into the wound
- Administering systemic antibiotics parenterally (*other than by mouth*) at the beginning followed by oral dosing.
- Prescribing anti-inflammatory analgesics to provide pain relief. NSAIDs (non-steroidal anti-inflammatory drugs; e.g., butorphanol, meloxicam, preferably celecoxib) or synthetic opioids may be used as needed.
- Testing for systemic infection in more advanced cases of decubital ulceration.
- Performing a complete blood count.
- Taking swabs regularly from within the abscesses for fungal and bacterial cultures. *E. Coli*, *Staphylococcus*, and *Candida albicans* are commonly isolated pathogens [4].

7.7 Treatment of Advanced Cases

Advanced cases may warrant surgical debridement (*cleaning and cutting away of dead tissue*) of fibrotic and exudative material as well as attempts to close the wound with sutures. Debridement should be approached cautiously since hemorrhaging can occur from the decubitus (*pressure sore*). Surgical excision of the abscess or amputation of a severely traumatized digit may be indicated [4].

Surgery is often necessary to repair damage to the tendons and ligaments. This is a long, slow process, and it may take months before the feet are healed. Even after healing is complete, the foot may still be tender for several weeks. Preventing trauma and maintaining the patient on soft footing is important to avoid recurrence. Waterfowl should be returned to the water as soon as possible to prevent other problems [4].

Treatment for Grade IV should include drainage, irrigation, and closing of the wound when the infection has been resolved. The prognosis is fair. Treatment for Grade V to VII lesions must be vigorous, and the prognosis is guarded [4].

For more information on novel treatments for pododermatitis, see Appendices B and C).

8. Consequences of Neglecting to Provide Treatment

8.1 Pain and Infection

If the bird owner notices the formation of these sores, initiates veterinary treatment, and makes positive changes to the bird's living environment, the prognosis for healing is good. However, without veterinary attention and environmental improvements, the sores typically turn into painful abscesses, which enable opportunistic pathogens (usually *S. aureus*) to breach the surface of the thinning skin [3].

The pain from these lesions causes increased weight-bearing on the unaffected foot, forcing the bird to bear its weight disproportionately. As a result, many birds suffer from bilateral pododermatitis. The plantar location of the lesion is constantly under forces of pressure, movement, and contusion (*bruising*); in addition, the bird's feet are constantly exposed to contaminants [7]. These birds are prone to arthritis as well.



Figure 24. Left: "Infectious pododermatitis with gross swelling of a foot in a snowy owl. The Central scab was removed and a large amount of liquid pus was present within the foot." Right: After application of a topical ointment and dressing, an interdigital bandage was applied as well as a custom-fitted silicone shoe" (image courtesy of B. Speer: Current Therapy in Avian Medicine and Surgery).

8.2 Necrosis, Lameness, and Decreased Quality of Life

In due time, the infection encroaches upon joints in the feet and bones in the legs, and surrounding tissues become necrotic. Ulcers may form on the feet, and the bird may become progressively lame [3]. “Birds beset by advanced and untreated bumblefoot can become so systemically infected that their lives are unsustainable” [3]. If left untreated, the lesions lead to crippling deformities, sepsis, and poor quality of life [7]. Bacterial infections that begin in the pads of the foot can ultimately lead to a bird’s death. Many surviving birds endure chronic abscesses and the amputation of a leg [3]. Unless the condition is treated, the infection will eventually eat into the bone and travel to other parts of the body. This is a painful condition that can lead to death [3].

8.3 Osteomyelitis Involvement

If systemic infection and pain can be controlled, the above therapy may be attempted. If the disease state becomes extreme, osteomyelitis occurs, and the prognosis for recovery decreases dramatically. The owner must be forewarned that the therapy will be of long duration, and the prognosis is poor. The owner and practitioner will need to discuss the ethics of such long, continuous treatment when the degree of disease is so advanced that the bird cannot stand without severe pain. Euthanasia will need to be considered under such circumstances [5].

8.4 Limb Amputation

If a bird has had a pelvic limb amputation, it is possible that pododermatitis will develop in the opposite leg. These birds benefit greatly from having soft, wide, padded perches and platforms provided for them. It is also possible that the wounds will be so severe that they do not respond to medical or surgical therapy, and the second foot or leg will need to be amputated. Euthanasia must be discussed if that occurs [13].

9. Prevention of Pododermatitis

Pododermatitis is easier to prevent than to treat. Bumblefoot may be prevented by taking the proper steps to ensure that the bird’s living conditions are correctly designed and it is given a nutritious diet. Prevention of pododermatitis involves constant vigilance for early signs of hyperkeratosis, baldness, flaking of the skin of feet and legs, redness or swelling. Early correction of the underlying causes will avert future severe disease [10].

9.1 Choosing the Right Cage

Cages should be large enough to accommodate several different types of perches. Flight pen and cage construction should contain vertical bars for climbing; these will help prevent trauma to the footpads when the bars are gripped. Care should be taken to make sure that the wire is smooth and contains no sharp places which could puncture or scratch the feet. Even powder-coated cages may contain sharp points that could damage the feet. Any rough places should be sought out and smoothed over with a file [10].

For large birds housed in wire enclosures, the walls of the enclosure should be designed with vertical bars or solid barriers to minimize the tendency for hanging from the wire. Selection of proper perch size, shape, and covering for a particular species of bird is very important [10].



Figure 25. The author's cockatiel in a small cage lined with towels on a platform. A smaller cage is advised because of the bird's poor mobility. This bird has severe arthritis without pododermatitis. Toys around the perimeter and on the door prevent him from falling down between the platform and bars. Birds with arthritis or bumblefoot need to be on soft surfaces at all times.



Figure 26. The author's bird in a bin with towels layered for softness. When arthritis becomes very painful, or painful foot sores are present, placing the bird in a bin on towels is an alternative to the cage. There are no bars, multiple towels will protect the feet, and the bird will move about much easier. Food, water, and toys may be placed in the bin with the bird. For bumblefoot, additional heat from a heating pad is contraindicated because it will aggravate the condition, making any inflammation, infection, or irritation worse.

9.2 Perches

The perches should be of various textures and sizes so the bird is not standing on the same plantar surface all the time. They should be of different shapes: oval or flat are better than rounds ones all of the same size. Rough-textured perches, such as concrete and sandpaper should NEVER be used since they will upbraid the tissue of the foot. Perches that are made of plastic and dowel wood, perches that are too small or too large, warming perches and those that have no variance in size, should not be used [15].

Perches that are too smooth will force the bird to grasp tighter all the time, and he can easily fall. They should vary in diameter and offer the bird alternating resting places for the plantar surface of the foot. Rope perches (such as the Booda perches) come in a variety of sizes, and along with natural tree branch perches, grape wood perches, and platform perches, provide a good standing surface.



Figure 27. Stage VI pododermatitis (image courtesy Brisbane Bird Vet; used with permission).

Perches that are both too hard and too smooth (such as dowel and Manzanita), plastic perches, sharp-cornered perches, rough pedicure perches, sandpaper and concrete perches should be removed and replaced with rope perches. Hard perches should be wrapped with a cohesive material such as Vetrap™ or that which can be purchased at a drug store. This will provide both padding and changes in diameter when the material is wrapped at varying intervals and thicknesses [6]. (The owner can wrap the harder perches with rope, not string, cohesive wraps such as Kroger's Tender Tape®, moleskin tape, Vetrap™, strips of flannel or fleece, or other soft material, to protect the bottom of the feet.)



Figure 28. Grade VII infectious pododermatitis in a chicken (image courtesy Farmer's Weekly).

Platform perches are very comfortable for birds. They should be covered with thick, soft padding. *(You can purchase flannel fabric and cut several layers to fit the platform, keeping them in place with binder clips)*. Place multiple layers of soft towels or other soft cloth on them to soften the surface [6]. *(Do not use paper towels or other fabric due to their rough texture; in addition, both could be easily ingested)*. These layers also may be secured with binder clips. If the sores are not too bad, loose paper towels may be placed on top of the secured ones for easy cleanup. These cloth towels must be laundered daily or whenever soiled, so you will need several [6].

Natural perches with different circumferences and textures are preferred. Birds should be encouraged to perch in different places and varying surfaces. This can be achieved by placing food and water dishes in different areas and changing the position of the favored perches [6]. *(Some people think birds choose a favorite perch when in reality they are choosing a preferred space in the cage. Take note of that and put the softest perches there)*.

9.3 Cage and Enclosure Flooring

The cage and the enclosure flooring can be a problem. Wire should never be used on the floor of the cage or structure. It can damage the feet and cause cuts and bruises. Hard or wire flooring should be covered with newspaper, soft towels or some other material to protect the feet, facilitate a more comfortable surface on the floor, and speed the healing process. **Any surfaces a bird touches should be carefully sanitized and kept clean** [6].



Figure 29. Padding perches with foam or Vetrap™ helps prevent bumblefoot. In Burgmann, Symptoms and treatment of bumblefoot (images courtesy of Hagen Avicultural Research Institute; used with permission).

9.4 Proper Nutrition

Nutrition is extremely important. Many affected birds are primarily seed-eaters. Feeding a balanced diet of a few pellets (*if desired but not necessary*), some seeds, fresh fruits and vegetables, and some human foods is critical, as is providing fresh water for bathing and drinking. Proper nutrition often will prevent or reverse early bumblefoot in Psittaciformes. Diet should be corrected to promote needed weight loss for obese birds by decreasing caloric intake and to increase general nutritional balance, with emphasis on replacement of Vitamin A precursors [5].

9.4.1 Excess Protein

Stored, excess protein promotes the growth of internal bacteria which are excreted through the skin. In areas where there are feathers, those feathers will usually absorb the protein. In bare areas, such as the feet, these bacteria will present themselves as pink, red and then blue "calluses." These most often show up on the bottom of the feet; however, they may also appear on the top or on the tips of the toes, above or under the bird's toenails. It is important to reduce the protein in the bird's diet to stop the progression of this condition [6].

9.4.2 Vitamins, Minerals and Supplements

Birds require supplemental vitamins and minerals to aid in the prevention of other diseases. Birds require Vitamin A and biotin (a B-complex vitamin) supplementation to ensure healthy skin development. Deficiencies in these vitamins may result in pododermatitis and focal hyperkeratosis (plantar corns). Bird owners should provide multivitamin, mineral, and essential fatty acids/amino acids supplementation to prevent these diseases [11].

For the affected bird, initial injections of Vitamins A, B-complex vitamins, and Vitamin D3 are advised, along with continued use of oral supplementation of multivitamin/mineral/essential fatty acid/amino acid preparations. Proper vitamin and mineral products may be recommended by your avian veterinarian [11,15]. Omega 3 and 6 essential fatty acids may be added in the form of Vectomega®, available through your avian veterinarian [9].

9.5. Sanitation

Proper hygiene is of the utmost importance in preventing bumblefoot.

- Cages and perches need to be cleaned and disinfected daily to avoid contamination from fecal matter and bacterial growth on surfaces and in food.
- Soft foods should be removed within two hours to prevent bacterial growth.
- Wipe down any surface that fresh foods have been on as soon as the food has been removed to prevent bacterial growth
- Seed, food, and water cups should be checked frequently during the day for droppings.
- Food and water cups need to be cleaned daily and replaced with fresh food and water as needed.
- The grates and trays of the cage must be cleaned daily since many birds spend time on the bottom of their cages where they may come in contact with the droppings. Paper towels on the grates (or trays if there are no grates) will make clean-up easier.
- All play areas must be kept very clean. Any play surface is a potential source of bacterial and fungal pathogens that could invade the surface of the bird's feet.
- T-stands, toys and anything the bird encounters or stands on must be kept scrupulously clean. Droppings, regurgitation, and soft foods should be cleaned up immediately to prevent consumption, reinfection and transmission of disease.
- Care must be taken to choose the cleaning product that will not harm the healthy or damaged tissue. All cleaning products need to be dry before allowing the bird to stand on them [16]. White vinegar (2 ¼ cups to a gallon of water) is a good cleaning liquid.
- **Do not use substrates on the bottom of the cages. These include nut shells, wood chips,**

grains, corn husks, moss, pine cones, bedding made for reptiles and small mammals—any type of bedding. These not only provide opportunities for bacterial and fungal spores to grow, they put dust into the air that harm the bird’s breathing and make it impossible for the owner to observe the droppings. Use plain newspaper, and place it where the bird cannot reach it.

9.6. Exercise

Exercise will aid in preventing pododermatitis. Allow the bird out-of-cage time frequently throughout the day so that it can fly and strengthen its legs and wings; this will take the pressure off the feet. Exercise will also aid in lowering the obese bird’s weight. If the bird does not fly, allow it to walk on the floor. This will also benefit the arthritic patient [8].

Conclusion

Pododermatitis is a disease that is easily preventable with the proper environment and nutrition. In the early stages, it is somewhat easy to control, and reversing the disease process is possible. In later stages, however, it becomes increasingly more difficult to treat and can, eventually, lead to permanent crippling and even death; therefore, the bird owner is advised to be continually vigilant, observing the condition of the bird’s feet on a daily basis. At the first sign of a lesion or bruise on the foot, the diligent owner should change any perches that might be causing it and take the bird to the avian veterinarian for diagnosis and treatment. When treatment and changes in diet and husbandry are initiated early in the disease, the chance of recovery is very good.

Appendix A - Raptors, Poultry, and Waterfowl

In captive raptors, bumblefoot is a common medical condition, even though it is never seen in the wild. Some raptor species appear to be more susceptible to this condition than others; falcons present with this frequently, but it is rarely seen in hawks. It is a result of poor nutrition, obesity, inadequate perches, lack of exercise, poor blood circulation to the foot, and cardiovascular changes at the end of the hunting season [17].

Penetrating wounds or bruising of the feet may be predisposing factors in raptors and waterfowl. Grades I to III lesions may not be discovered in raptors; most are not seen until they have more severe lesions, often Grade IV or V [1].

Raptors are prone to bruising and abrasions on the plantar surface of the feet from jumping from a perch onto a hard surface, hanging from cage wire by their feet, or being forced to stand on hard perches or cement. Any soft tissue or orthopedic injury involving one leg or foot may cause excessive weight-bearing and secondary pododermatitis on the contralateral foot (*the foot on the other side*) [4].

Overgrown talons cause improper weight distribution on the plantar surface of the foot, especially in falcons, or self-inflicted puncture wounds of the metatarsal pad. Other traumatic injuries to the foot that can lead to bumblefoot include bite wounds from the prey, punctures from thorns or quills, and trap injuries [4].



Figure 30. "Severe bumblefoot (Grade VI) in a grey heron (*Ardea cinerea*). Severe tendon damage of the first digit was also present and euthanasia was warranted in this case" (image from Glen Cousquer. Wound assessment in the avian wildlife casualty. Used with permission).

A bird's inactivity in an enclosure, limiting its ability to fly, is a contributing factor. In a study by P.T. Redig (Ford: Raptor Medicine Master Class), raptors that were housed outdoors and were able to exercise did not develop bumblefoot, regardless of their perching surfaces. The group that was maintained indoors on the same diet developed bumblefoot irrespective of the perching material [4].

For large birds and raptors housed in wire enclosures, the walls of the enclosure should be designed with vertical bars or solid barriers to minimize the tendency for hanging from the wire. Selection of proper perch size, shape, and covering for a particular species of bird is very important. Perches wrapped with hemp rope or covered with Astroturf work well for most raptors. Falcons do best on flat shelf or block perches covered with short Astroturf or cocoa mats. Strict sanitation of the facilities and feet is important to minimize bacterial infections. Liquid bandage products work well for minor skin cracks or torn talon sheaths in raptors [4].



Figure 31. Red-tailed hawk at “Wild Care” in Eastham, MA. One talon had to be removed due to a serious infection in the feet. She is on ball bandages. The caregivers are optimistic about her ability to be returned to the wild” (image by Eric Williams in Cape Cod Capecast).

In most cases, treatment involves the surgical removal of scabs and adjacent necrotic and purulent (*pus-filled*) tissue, followed by suturing to achieve healing by first intention (*the wound is held together by a blood clot or sutures*). Sometimes antibiotic-impregnated beads are placed within the wound cavity to improve the rate of healing. If the opening is larger, sutures are used along with hydrocolloid dressings to promote healing [17].



Figure 32. Grade VII “Bumblefoot infection has spread across both of this bird’s feet. The areas affected look blackened” (image by Elliott Simpson, courtesy of The Veterinary Expert; used with permission).



Figure 33. Grade VI “A discrete bumblefoot lesion, showing typical positioning at the weight-bearing position on the base of the foot.” (*Discrete refers to a lesion that is localized as opposed to diffuse in which there are multiple lesions present*) (image by Elliott Simpson, courtesy of The Veterinary Expert; used with permission).



Figure 34. “Chickens cope incredibly well with legs bandaged! This bird has had surgery for bumblefoot. The bandages cover the surgical site as well as allowing pressure relief to the feet whilst the area in question heals” (image by Elliott Simpson, courtesy of The Veterinary Expert; used with permission).

Captive waterfowl are also at increased risk for developing this condition because of their heavy-bodied nature and the amount of time they spend standing around rough, hard surfaces around pools or pens. Waterfowl may suffer penetrating wounds and bruises on the feet which lead to pododermatitis [18].



Figure 35. A silver gull with a tibiotarsus fracture on its right leg (*Larus michahellis*) on his solid left foot, burdened with more weight than normal, resulting in pododermatitis ((image courtesy of K. Gerbaga Özsemir [14]).

Pododermatitis is common in poultry. VAP's are more commonly used in mammalian patients, but are sometimes used to treat avian patients requiring long-term intravenous therapy or serial blood collection. Vascular Access Ports offer the advantages of ease of access, reduced trauma and handling of the patient, and the accurate delivery of large volume of tissue-irritating drugs. Although this technique is used for mammals, it is still considered a novel treatment for avian species [13].

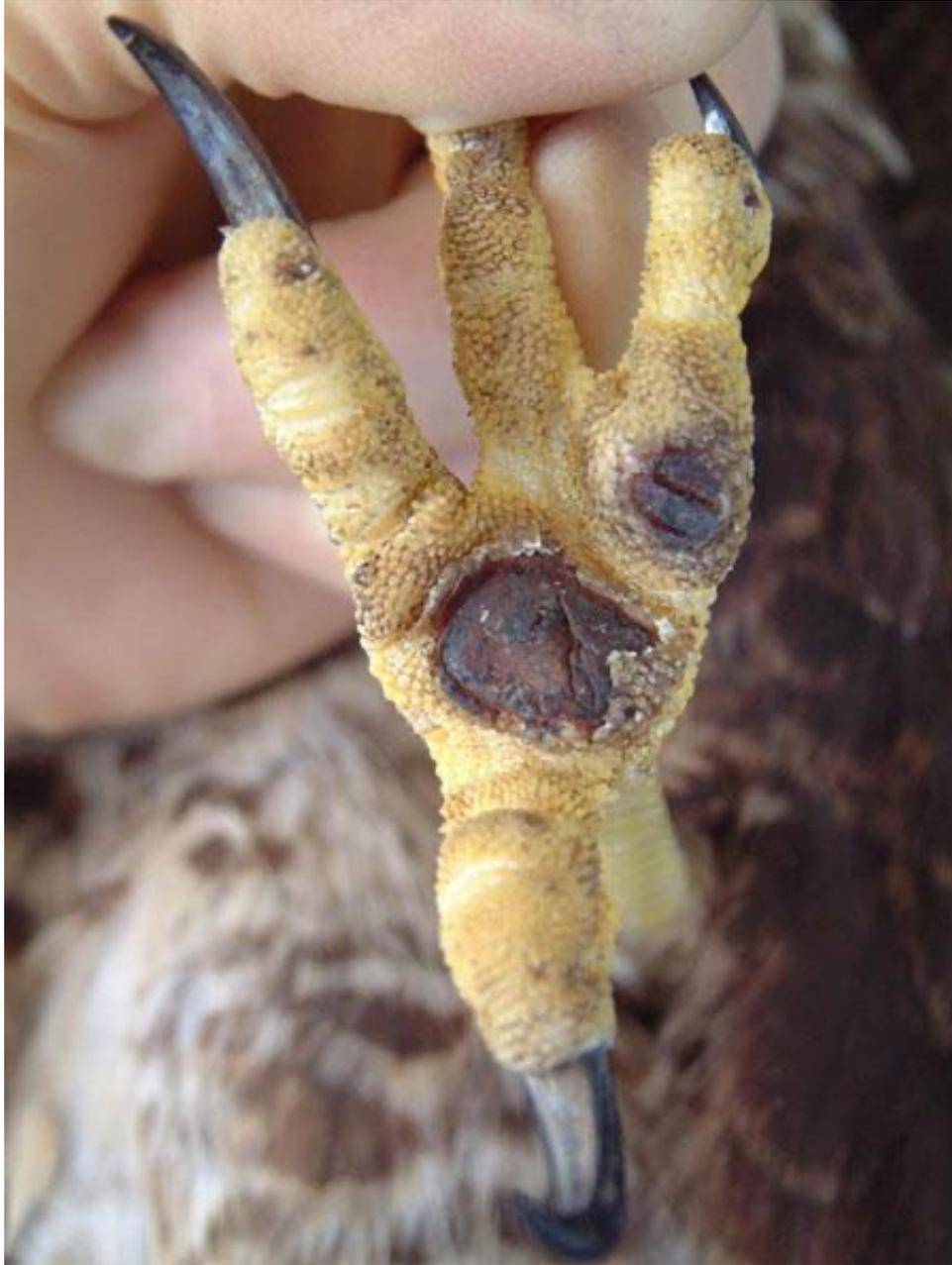


Figure 36. Grade VI bumblefoot foot in a buzzard (*Buteo buteo*). This bird had been shot and had developed severe arthritis of the tibiotarsal joint of the contralateral limb. The bird was emaciated and had a heavy worm burden. Excessive weight bearing on the healthy leg, coupled with malnutrition, is likely to have resulted in the lesions depicted (image from Glen Cousquer. Wound assessment in the avian wildlife casualty. Used with permission).



Figure 37. Grade VI pododermatitis in a chicken (image courtesy of Monica Talbett; used with permission).



Figure 38. Grade VI pododermatitis. The chicken's foot before surgery (image courtesy of The Chicken Chick).



Figure 39. The chicken's foot four months after surgery (image courtesy of The Chicken Chick).

Appendix B - Technique: Laser Treatments

In 2014, ten veterinarians met during an Association of Avian Veterinarians conference to discuss the use of therapeutic lasers in treating avian and other exotics patients. Lasers are being used in veterinary medicine with positive clinical results, and low-power therapeutic lasers have proven effective for the treatment of wounds, reduction of inflammation, and modulation of pain [19]. The results of the discussion are as follows:

- All of the attending clinicians had used therapeutic laser treatment with birds and other exotics in their clinical work.
- These uses included:
 1. Healing wounds that have resisted previous therapies
 2. Painful conditions

3. Wounds and skin infections
4. Postsurgical incision treatment
5. Osteoarthritis
6. Pododermatitis
7. Any inflammatory condition or traumatic lesion [19].

When asked about the kind of response they observed with therapeutic laser treatment compared to routine care, the practitioners responded positively:

- One practitioner responded that several cases of pododermatitis in small mammals and birds had improved, in some cases dramatically, with the addition of therapeutic laser treatments
- Another mentioned that he had seen faster healing, a decrease in the severity of his wound cases, and improved mobility in the orthopedic cases.
- A third mentioned accelerated healing time, particularly in the dermal wound healing of the foot.
- Another clinician saw considerable improvement in a chicken with bumblefoot, both in improved weight-bearing and decreased inflammation after just one treatment.
- One veterinarian found that laser treatments greatly reduced the bacterial colony in a wound.
- Another clinician noted that the animals appear to tolerate the treatment very well and are even able to relax a little during the treatment [19].



Figure 48. Laser treatment being applied to a cockatiel with a chronic, long-term self-mutilation site. The bird responded to his one session two weeks before and received one more session just in case. A complete set of appropriate tests was performed on the bird over the last two years including bloodwork radiographs as well as a removal and biopsy of the affected skin to rule out damaged nerves” (image courtesy Vanessa Rolfe, The Bird and Exotic Hospital; used with permission).

A discussion of the advantages and disadvantages of therapeutic laser treatment in avian patients yielded the following results:

- The benefits:
 1. An increase in the level of healing for pododermatitis patients
 2. An adjunct to medical therapy alone
 3. Improved speed of treatment and response time, leading to less stress on the patient and better recovery and survivability of the patient [19].

- The drawbacks:
 1. Difficulty in objectively determining the effectiveness or success of the laser treatments
 2. The lack of specific protocols for the use of the laser
 3. The large amount of mis- or disinformation being spread, which serves to confuse the clinician
 4. The lack of scientific studies in the literature about laser use. Those that are published sometimes have limited access, so clinicians may not have been able to read them and thus may not feel comfortable with their use [19].

All concluded that the advantages significantly outweighed the disadvantages. Although lasers have been used for some time by veterinarians, they have not been used as long by avian and exotic veterinarians. All agreed that the differences between avian tissue and mammalian tissue warranted more careful study of the techniques involved and results gleaned from such use, and far more care needs to be taken when applying laser treatment to birds [19].

References

1. Cooper J.E., Harrison G. Dermatology. Avian Medicine: Principles and Application. Wingers Publishing, Inc. 1994. P. 632.
2. Van Sant F. The Integument: The Largest Organ System of Birds. Proc Assoc Avian Vet 2014. P?
3. Turner C. Bumblefoot in Birds. Wagwalking.com.
<https://wagwalking.com/bird/condition/bumblefoot>
4. Degernes L. Trauma Medicine. Avian Medicine: Principles and Application. Wingers Publishing, Inc. 1994. p. 425, 426.
5. Lightfoot, T. and Schmidt, R. E. (2008) "Integument", Clinical Avian Medicine. Available at: <https://www.ivis.org/library/clinical-avian-medicine/integument> (Accessed: 03 February 2021).
6. Kightley I. Bumble Foot: Causes and Treatment Options. Beauty of Birds.
<https://www.beautyofbirds.com/bumblefoot.html>
7. Ford S., Chitty J., Jones M. Raptor Medicine Master Class. Proc Assoc Avian Vet 2008. P. 173-190
8. Gerlock H. Bacteria. Avian Medicine: Principles and Application. Wingers Publishing, Inc. 1994. p. 967
9. Perpiñán D. Obesity in Parrots. The Veterinary Expert.
<http://www.theveterinaryexpert.com/parrots/obesity-in-parrots/>

10. Sander S. et al. Advancement Flap as a Novel Treatment for a Pododermatitis Lesion in a Red-tailed Hawk. *J Avian Med Surg* 27(4): 294-300, 2013.
11. Helmer, P. (2010) "Surgical Resolution of Orthopedic Disorders", *Clinical Avian Medicine*. Available at: <https://www.ivis.org/library/clinical-avian-medicine/surgical-resolution-of-orthopedic-disorders> (Accessed: 03 February 2021).
12. Dumonceaux G., Harrison G. *Toxins. Avian Medicine: Principles and Application*. Wingers Publishing, Inc. 1994. P. 1047, 1048.
13. Miesle J. The Effects of Tobacco Use on Avian Species. In: Facebook group The Science of Avian Health File, Academia.edu, and Beauty of Birds website. 2017
13. Doneley, B., Harrison, G. J. and Lightfoot, T. (2006) "Maximizing Information from the Physical Examination", *Clinical Avian Medicine*. Available at: <https://www.ivis.org/library/clinical-avian-medicine/maximizing-information-from-physical-examination> (Accessed: 03 February 2021).
14. Gerbaga Özsemir K. Diagnosis and Treatment of Pododermatitis in Birds. *Turkiye Klinikleri J Vet Sci* 2018;9(2):62-8.
https://www.researchgate.net/profile/Kuebra_Gerbaga_Oezsemir/publication/329551287_Diagnosis-and-Treatment-of-Pododermatitis-in-Birds.pdf
15. Axelson D. *Avian Dermatology*. In: *Practical Avian Medicine: The Compendium Collection*. Ed: Heidi Hoefler. Veterinary Learning Systems, 1997. P. 200
16. Clubb S., Flammer, K. *The Avian Flock. Avian Medicine: Principles and Application* Wingers Publishing, Inc. 1994. P. 50, 56-58.
17. Samour, J. (2011) "Management of Raptors", *Clinical Avian Medicine*. Available at: <https://www.ivis.org/library/clinical-avian-medicine/management-of-raptors> (Accessed: 03 February 2021).
18. Olsen J. *Anseriformes. Avian Medicine: Principles and Application*. Wingers Publishing, Inc. 1994. P. 923
19. Ritzman T. Therapeutic laser Treatment for Exotic Animal Patients, Round Table Discussion. *AAV. J Avian Med Surg* 29 (1):69-73, 2015
20. Wikipedia. Granulation tissue.