Select bacterial, fungal, and viral skin diseases of cattle, sheep, goats, pigs, and camelids

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These notes are an overview of some of the infectious dermatoses in non-equine large animals. There are an enormous number of infectious organisms that can infect the skin of these animals. As with small animals, some of these diseases are zoonotic. And because of economic loss due to hide damage, decreased milk production, or negative impacts on reproduction and weight gain, some of these diseases are a major herd health concern. The focus will be on diseases that affect large animals in North America.

Bacterial skin diseases

Staphylococcal skin infections

General:

Staphylococcus aureus is the most common species in food animals. *S. aureus, S. chromogenes, S. hyicus* have been isolated from cattle skin. *S. aureus, S. haemolyticus, S. warneri, S. epidermidis, S. chromogenes, S. caprae, S. hyicus,* and a variety of other species have been isolated from goat skin. *S. aureus, S. xylosus, S. epidermidis* have been isolated from sheep skin. *S. aureus, S. hyicus, S. chromogenes, S. sciuri* have been isolated from pig skin. *S. aureus, S. hyicus* considered normal skin flora in most food animals. Udder, teats, and nasal/oral/perineal mucous membranes are the most common colonization sites.

Clinical Features:

Similar to small animals, skin infections are rarely primary, other factors frequently contribute to the occurrence of staphylococcal skin infections. In large animals these can include: stress from parturition/lactation, poor nutrition, overcrowding, transport, poor hygiene, coarse feed or bedding, external or internal parasitism, other skin disease, or systemic illness.

There are three general presentations to consider: impetigo, folliculitis, furunculosis. Impetigo is a term used more commonly in human dermatology to specify non-follicular papules and pustules around the mouth in young children usually caused by a *Staphylococcus* or *Streptococcus* species. In veterinary dermatology it generally refers to a non-follicular pustular eruption. These pustules progress to crusts, epidermal collarettes, and erosions. In large animals this occurs primarily on the teats and udder, so dairy cattle are more commonly affected. Milking equipment and lack of sanitization can be predisposing factors. While mild lesions are not necessarily problematic, they can progress to mammillitis or mastitis, though there is some debate about the relationship.

Folliculitis refers to an eruption of follicular papules that progress to crusts, epidermal collarettes, alopecia. Lesions can be present on any body region depending on which underlying factors are present, but sparsely-haired areas such as periocular regions, muzzle, ventral abdomen, medial thighs might be more commonly affected. Furunculosis is an extension from folliculitis, with deeper and more inflammatory lesions than folliculitis, including edema, erythema, ulceration, nodules, draining tracts.

Udder dermatitis is a group of conditions in dairy cattle, also called udder rot, udder cleft dermatitis, flexural or udder seborrhea, necrotic dermatitis. There is overlap of early or mild forms with the clinical lesions of *Staphylococcal* intertrigo, though *Staph* species are not typically involved. There are three forms: friction between lateral aspect of udder and medial thigh, particularly around time of parturition; between quarters in the central fold or cleft,

particularly in older cows; and in the skin cranial to the two forequarters. The etiology is poorly understood. Lesions are exudative dermatitis with ulceration, necrosis, keratinous debris, foul odor, and pain sometimes manifesting as lameness. The most common organisms isolated include: *Fusobacterium, Trueperella, Treponemes*, occasionally *Staphylococci.*

Methicillin-resistant *Staphylococcus aureus* (MRSA):

MRSA is a major global concern for animal production, and as a reservoir for human infection. Numerous case reports of zoonosis, including hand dermatitis in dairy workers, and skin wounds in pig farmers, have been published, though some researchers question the direction of transmission given the lack of strain typing in older reports. Some animal-associated strains have been found in human outbreaks where no clear connection to animals could be detected. There are reports where humans affected with MRSA do not have complete resolution until their companion animals are also treated. Large animal veterinarians and their staff are much more likely than small animal veterinary staff to be nasal carriers of MRSA.

Lineages of Staph are grouped by their clonal complex (designated CC), and further subdivided by sequence type (ST). ST398 is the major MRSA strain associated with swine, though it has been recovered from calves, chickens, dogs, horses, pigs, rats, and humans. Its spread around the globe as a community-acquired strain suggests that it has relatively non-specific host requirements.

Differential diagnoses for *Staphylococcal* skin infections:

There are a large number of disease problems that can lead to teat or udder lesions. Dermatophytosis, dermatophilosis, and filarial dermatitis (i.e. *Stephanofilaria*, *Pelodera*) and the primary non-viral infectious differential diagnoses. A huge number of viral dermatoses can present as teat or udder lesions. These include: parapoxvirus bovis-2 (pseudocowpox), parapoxvirus ovis (contagious pustular dermatitis or ‘orf’), herpesvirus (bovine herpes 1, 2,3; bovine viral diarrhea virus, bovine papular stomatitis virus (rarely). Bluetongue virus, foot and mouth disease, vesicular stomatitis, ovine herpes type 2 (malignant catarrhal fever), are very uncommon to rare but reportable. Other skin diseases as indicated by species such as ectoparasitism, nutritional dermatoses (zinc-responsive dermatosis), photosensitization, pemphigus foliaceus, sterile eosinophilic folliculitis/furunculosis are also considerations.

Diagnosis:

Lesion appearance and location should increase clinical suspicion. Impression cytology of pustules or under crusts should show coccoid bacteria, neutrophils, and other inflammatory cells. Aerobic culture is useful to confirm diagnosis and guide systemic antibiotic therapy if it is indicated. Traditionally identification of various *Staphylococcal species* has been based on colony morphology and phenotypic tests in cultures on blood agar (i.e. types of hemolysis, colony pigment), and biochemical tests (i.e. coagulase, catalase, maltose). These phenotypic and biochemical tests helped discriminate between members of the species. With the advent of molecular techniques, more species have been detected, and the traditional tests do not necessarily differentiate between these species. So in a research setting, or investigation of a zoonotic episode or herd problem, molecular typing techniques should be used. These include: multi-locus sequence typing (MLST), *spa* typing, or whole-genome sequencing. Histopathologic findings depend on level of infection but can include subcorneal pustular dermatitis with intralesional gram-positive cocci, suppurative luminal folliculitis, or pyogranulomatous furunculosis.

Treatment:

In order to practice good antibiotic stewardship, systemic antibiotic therapy should not be the first choice for mild, localized, or superficial lesions. Underlying causes of skin infection should be addressed such as ectoparasitism, housing, hygiene, stress, nutrition. Topical therapies if feasible are similar for small animals, such as chlorhexidine or povidone-iodine. Systemic therapies should be based on culture and susceptibility and legality for use in food-producing animals.

Porcine-specific *Staphylococcal* skin infections:

Exudative epidermitis (EE), also called "greasy pig disease" is a widely-recognized disease of suckling and recently weaned piglets. While most cases are mild it can sporadically cause extensive morbidity and mortality. Average age of affected animals is 4 days to 6 weeks of age, with high rates of morbidity (up to 100%) and mortality (up to 95%) reported in certain outbreaks. Lesions vary from reddish to coppery skin discoloration and thin scales in axillae and groin, to widespread greasy brown exudate with oral erosions or ulcerations. Coronary band and heel erosions and ulcers can also occur. More classic *Staphylococcal* lesions of pustules can be seen in peracute cases on the nose, lips, tongue, coronary band. Early lesions on the abdominal skin can show positive Nikolsky sign. Septic arthritis has been associated with *S. hyicus* infection in the absence of skin lesions. Lesions are typically not pruritic and even severely affected animals are not pyrexic, but lesions can be painful on palpation. Death is usually due to anorexia and dehydration. Some piglets survive but have stunted growth with chronic skin changes. *S. hyicus* strains (rarely *S. chromogenes* or *S. sciuri,* some reports of *S. aureus* including MRSA) with exfoliative toxins (Exh A, B, C, D, SHETA and SHETB). These toxins digest desmoglein-1, a similar mechanism to scalded skin syndrome and bullous impetigo in humans. *S. hyicus* is normal skin flora so some underlying skin abnormality must be present for it to gain entry and cause disease. Theories include abrasions from rough housing, minor lacerations from bite wounds from fighting with littermates. Co-infection with porcine circovirus type 2 or porcine parvovirus might be predisposing factors.

Differential diagnoses include dermatophytosis, dermatophilosis, ectoparasitism (sarcoptes), pityriasis rosea, zinc deficiency, biotin deficiency, trauma, swine pox infection. If vesicular lesions are present the differentials should include those associated with reportable disease outbreaks such as foot and mouth disease, swine vesicular disease, vesicular stomatitis, vesicular exanthema.

Diagnosis is based on clinical findings, including impression cytologies. For disease outbreak investigation and treatment bacterial culture is important. Due to variable antibiotic use patterns on different farms for other pathogens (respiratory or digestive tract), and not all cases being due to *S. hyicus*, culture provides valuable information to determine the source of infection and the most appropriate treatment. High rates of antimicrobial resistance reported, ranging from 71% resistance to ceftiofur to 97% resistance to penicillin G. Histopathology would should subcorneal to intraepidermal vesicles and pustules with neutrophils, occasionally acantholytic keratinocytes and coccoid bacteria.

Prevention instead of treatment is the goal. This is accomplished via hygiene and husbandry, addressing housing, crowding, needle teeth. Both topical and systemic therapies are reported, these should be based on bacterial susceptibility.

Other bacterial skin infections:

Erysipelothrix rhusiopathiae

A gram-positive pleomorphic rod facultative anaerobe that is an oral and tonsillar commensal in many mammals. It most commonly affects outdoor unvaccinated hogs ages 3 months to 3 years, though it has been reported in a variety of species including dogs, and captive marine mammals. There are three clinical forms: subacute, acute, and chronic. The subacute for presents as erythematous papules and wheals on throat, neck, pinnae, abdomen, and thighs that progress to rhomboidal plaques. This is the classic diamond skin disease. These plaques become necrotic in the center. The acute form includes fever, depression, anorexia, and lameness that accompany purpural skin discoloration of the jowls, abdomen, pinnae, legs. And the chronic form consists of ulceration and necrosis of affected skin, occasionally necrosis and sloughing of the pinnae, tail, and feet might occur. The primary differential diagnosis is infection with *Actinobacillus suis.* Diagnosis is by aerobic culture; this is a slow-growing organism so molecular techniques might be necessary. Treatment with ampicillin or amoxicillin is typically effective; fluoroquinolones have been used in small animals. Most swine breeding operations use a commercial vaccine to prevent infection. *E. rhusiopathiae* is zoonotic. Most human infections are a minor self-limiting rashes on areas of contact with infected animals. These include bright red to purple swellings on a finger or hand, sometimes associated with pain or fever. There are rare reports of septic arthritis and septic endocarditis in people.

Dermatophilosis congolensis

A gram positive facultative anaerobe actinomycete with two morphologies: filamentous hyphae and motile zoospores. The hyphae branch by both transverse and longitudinal separation so they eventually form packets of coccoid cells. It is these cocci that mature into flagellated ovoid zoospores, the infectious stage of the organism. Many authors describe the packets of coccoid cells as having an appearance similar to railroad tracks. The natural reservoir has not been identified, but infectious debris (scales, hairs, crusts) persisting in the environment from affected animals is suspected to contribute. The skin disease it causes is also called rain rot, rain scald, mud fever, lumpy wool, strawberry foot rot, or streptothricosis. It is characterized by exudative dermatitis with heavy crust formation that can cause significant economic losses, particularly in tropical areas. Spread is from infective crusts contaminating the environment, probably also tick bites, possibly other biting insects. It is most common in warm humid environments. Cattle, sheep, goats, camelids can all be affected. Swine are less often affected unless they are housed outdoors. Underlying skin trauma or disease, or systemic illness, are often confounding factors. Isolated cases have been reported in small animals and exotic species. Lesion location varies based on exposure to excessive moisture: dorsally-oriented lesions indicate standing in prolonged rain versus lower limb lesions indicate standing in mud or standing water. Any body region can be affected. Lesions are classic tufted papules and pustules that coalesce with exudation matting hairs together. These crusts can be pulled off in one large piece, often described as paintbrush crusts. Usually there is thick purulent green discharge underlying these crusts. Lesions are typically more painful than pruritic. Advanced cases can have edema, fever, regional lymphadenopathy. Depending on underlying factors there can be severe illness and death. Differential diagnoses include: dermatophytosis, *Staphylococcal* folliculitis, ectoparasitism, sterile causes of folliculitis/furunculosis, zinc-responsive dermatosis, contagious viral pustular dermatitis (sheep/goats), pemphigus foliaceus (goats) Diagnosis can be simple with cytology. Impression smears of exudate under crusts shows packets of coccoid cells, with inflammatory cells. If there is no exudate, soaking crusts in saline, mincing them with a scalpel or spatula, then spreading the solution on a slide to dry and stain can also be diagnostic for

finding the filamentous packets of coccoid cells. Aerobic culture is an option though the lab should be informed of the suspect organisms because of it's need for carbon dioxide and relatively slow growth. PCR is being used with greater frequency for epidemiologic surveys. And histopathology would show neutrophilic luminal folliculitis and dermatitis with palisading crusts with gram-positive cocci in branching filaments. As with other bacterial skin infections, a major component of treatment is resolution of underlying causes, such as providing shelter from rain or moving to a drier pasture. Topical therapy with lime sulfur or chlorhexidine after removing matted hair and crusts can speed resolution. Care should be taken to avoid contaminating the environment with these crusts. Systemic antibiotic therapy might be needed for severe cases or in animals with complex underlying problems. Potentiated sulfonamides or penicillins are typically effective. *D. congolensis* is zoonotic. Lesions on people usually occur on contact areas, such as hand or arm, and are pruritic or painful erythematous pustules or nodules.

Causes of abscesses or abscess-like lesions:
There are a variety of bacterial causes of abscesses and abscess-like lesions in large animals, some of them are the same organism, or same genus, as those that cause similar deep lesions in small animals. In addition to the four detailed below, *Trueperella pyogenic* (formerly Arcanobacterium pyogenes), *Nocardia* spp, *Streptococcus* spp, *Fusobacterium* spp are also possible causes of abscesses.

Corynebacterium pseudotuberculosis is a gram-positive facultative anaerobe that causes caseous lymphadenitis in small ruminants and cattle. It can also be a cause of ulcerative lymphangitis in these same species, and can infect horses too. Clinical signs include firm subcutaneous nodules or draining abscesses or granuloma-like lesions. These typically occur where there has been a wound, excessive moisture, or fly strike. Differential diagnoses include other causes of abscesses, and deep fungal infections. On cytology *C. pseudotuberculosis* is an intracellular pleomorphic bacterium, taking on coccoid, club, or rod shapes that can be singular or in clusters. Histopathology shows pyogranulomatous dermatitis and panniculitis; organisms are not high in number so may not be seen.

Actinomyces bovis is an oral commensal which explains the common manifestation as "lumpy jaw" due oral trauma. Firm swelling over the mandible occurs and then commonly ulcerates and drains. This discharge may contain "sulfur" granules which are 1-3mm diameter yellow to white granules the consistency of sand. Sulfur granules are called this because of their color, not because they contain sulfur. They consist of masses of mycelial fragments with a rosette of peripheral club-shaped structures, held together by a protein-polysaccharide capsule that evades host defenses by inhibiting phagocytosis. When viewed histologically the surrounding capsule material is often described as Splendore-Hoeppli material, brightly eosinophilic aggregates. S-H material arises in many different conditions, it is not associated with just one infectious organism, or even only infectious processes. *A. bovis* is a gram positive anaerobe, in filaments or shorter V, Y, T forms on cytology and histology. Diagnosis by culture requires prolonged growth in anaerobic conditions. On histopathology there is pyogranulomatous dermatitis and panniculitis; organisms are not high in number so may not be seen.

Actinobacillus lignieresii is another oral and rumenal commensal. The classic, though actually uncommon manifestation is "wooden tongue" due to pyogranulomatous glossitis. The more

common presentation is firm ulcerated nodules to abscesses in the mouth, jaw, neck region. Discharge may contain “sulfur granules" as for Actinomyces. *A. lignieresii* is a gram negative coccobacillus or rod.

Atypical mycobacteria (nontuberculous mycobacteria). These are gram positive acid-fast rods that are widespread in the environment though infection is rare. As for small animals, infection is due to traumatic inoculation likely combined with some degree of host immunocompromise. *M kansasii, M. ulcerans* have been isolated. Clinical presentation can be subcutaneous nodules or abscesses, or ulcerative lymphangitis consisting of a swollen limb and with corded lymphatics (palpable and enlarged), firm to fluctuant nodules becoming abscesses with draining tracts; exudate can be clear to purulent. Differential diagnoses include: dermatophilosis or other deep fungal infection, opportunistic mycobacterial granuloma, C. pseudotuberculosis, T. pyogenes, A. bovis, A. lignieresii. Diagnosis is based on demonstrating acid-fast rods either on cytology or histopathology, which shows nodular to diffuse granulomatous dermatitis. Culture is not practical as these organisms are difficult to grow; PCR can be used where available. Affected animals will test positive on a tuberculin test. Farcy is the colloquial name for infection with *M. senegalese*, which is endemic in parts of Africa, Asia, and South America. It has a prolonged course leading to systemic organ infection, and eventual death.

<u>Fungal skin diseases</u>

Dermatophytosis

General:

Dermatophytes are fungi adapted to feed on keratin. They are only found in the cornified layers of the skin and/or hair shafts. Proteases, adhesins, fungalysins, keratinases are produced by various species to aid adhesion to and penetration of the skin and hair. These enzymes also digest keratin, providing nutrients for the growing fungus. Hyphae grow down a hair shaft, stopping at the zone where keratin is produced (Adamson’s fridge, keratogenous zone) and are maintained by the continuous formation of keratin as the hair shaft grows. Dermatophytosis in large animals is common and widespread. As with other infectious dermatoses, young animals are commonly affected because of their naïve immune systems, or animals with underlying skin problems or systemic illness. Stress from overcrowding, transport, poor nutrition or poor hygiene can all be contributing factors.

There are a number of dermatophyte species affecting large animals. *Trichophyton verrucosum* is most common in cattle, sheep, goats, camelids. *T. nanum* (*N. nanum*) in swine, less commonly *M. canis, M. gypseum* (*N. gypseum*), *M. persicolor* (*N. persicolor*), *T. mentagrophytes, T. verrucosum, T. tonsurans*.

Clinical aspects:

Lesions are common on the face, particularly periocular regions and periauricular regions, though they can be generalized. Tufted papules progress to thick adherent grey or white crusts. Alopecia and scale can also be primary lesions. Occasionally the lesions are painful but typically are not pruritic.

Diagnosis is by demonstration of fungal elements either on cytology from lesions or culture. The presence of fungal elements in affected tissue can be demonstrated by finding arthrospores on hairs via trichogram, or by finding arthrospores and/or hyphae on hairs in biopsy samples. It is important to note that the species affecting large animals do not always fluoresce with a Wood’s lamp so this is not necessarily useful for selecting hairs for trichograms or culture.

Dermoscopy might be useful in this aspect. Culture should be on Sabouraud's dextrose agar or dermatophyte test media (with is the same as Sabouraud's with phenol red added as a pH indicator and cyclohexamide, gentamicin, and tetracycline added to control contaminant fungal and bacterial growth). *T. verrucosum* requires thiamine and some strains require inositol for growth. Addition of B vitamins to the media is needed.
Differential diagnoses include Staphylococcal folliculitis, dermatophilosis, ectoparasitism, filarial dermatitis, zinc-responsive dermatosis, biotin deficiency.
Treatment:
Vaccination of cattle herds is common outside of the USA and has been used for eradication from dairy herds in some countries. The disease itself is typically self-limiting in 3-4 months in otherwise healthy animals. However secondary bacterial infection, or fly strike can lead to severe hide damage. The species causing dermatophytosis in large animals are also zoonotic.

Pythium insidiosum:
An oomycete, an aquatic fungus-like algal organism that is a pathogen of mammals in the tropics and subtropical regions. Most other pythium species are pathogens of plants. This is a rare infection in the US, predominantly seen in the southeastern states, but has been documented in dogs in central and Midwestern states. Swamp cancer is the colloquial name and describes how invasive and difficult to treat it can be. Phycomycosis, Florida horse leeches are other names. Skin lesions consist of ulcerated nodules and draining tracts which can be extensive. They occur on body regions exposed to standing water or mud, so the limbs or ventrum are often affected. Gastrointestinal and ocular infections can occur. Diagnosis is based on histopathology, culture on special media, serology, and PCR. On histopathology pyogranulomatous dermatitis is found with non-septate hyphae, enhanced on PAS or silver stains; prominent eosinophilic dermatitis can occur. Serology for anti-*P. insidiosum* antibodies and tissue PCR for the organism are available. Treatment in large animals is usually not pursued due to costs; long courses of systemic antifungal drugs combined with surgical resection are needed. There is a commercially available vaccine for horses and dogs, although efficacy research is on-going.

<u>Viral skin diseases</u>
Contagious viral pustular dermatitis
Caused by *Parapoxvirus ovis*, it affects sheep, goats, and camelids. It typically occurs in young animals (2-4 months of age) and is due to contamination of skin abrasions. Lesions consist of pustules and vesicles that progress to heavy dark yellow to brown or black crusts around the lips and nostrils; this can result in transmission to teats via nursing. The lesions can be painful and lead to reduced feeding behavior. Lesions on other body regions (oral cavity, interdigital spaces, coronary bands) can also be affected. Typically lesions are self-limiting in 2-3 weeks though a chronic form that lasts weeks has been reported. This virus is zoonotic. In humans it has been called orf, farmyard pox, contagious ecthyma. It causes painful umbilicated papules or nodules on areas in contact with affected animals, such as hands and fingers.

Cowpox (Feline cowpox)
An orthopoxvirus (same family as human smallpox), endemic in Europe and Asia, rodents are reservoir host, rarely produces disease in cattle but causes disease in cats, occasionally humans, has been reported in a dog. Lesions in people are indistinguishable from pseudocowpox lesions. Cats are infected while hunting rodents. Cutaneous clinical signs are erythematous crusted,

ulcerated plaques and nodules, typically on the head/neck/forelegs (body regions exposed to rodents). There is usually no pruritus associated with the skin lesions. Other clinical signs are uncommon but can include fever, decreased appetite, oral/gastrointestinal ulceration, diarrhea, nasal discharge, pneumonia. Typically resolves without treatment in 6-8 weeks in an otherwise healthy animal, but viral co-infections or immunosuppressive therapy can lead to fatal pneumonia.

Papillomaviruses:
These are universal viruses that infect keratinocytes, causing benign neoplasms. Younger animals are more commonly affected, though certain types affect adult animals.

Bovine papillomavirus	12 types	Notes
	BPV-1: teat fibropapillomas BPV-2: head/neck/shoulder fibropapillomas BPV-3: 'atypical' warts, all ages, low, flat circular non-pedunculated, do not regress BPV-5: 'rice grain' warts on teats, all ages, do not regress BPV-6: conical to branch-like warts on teats with long surface projects that frequently break off, leaving ulcers behind, do not regress BPV-7, 8, 9, 10, 11, 12, 13: no useful clinical information	BPV-1,2: responsible for equine sarcoids
Caprine papillomavirus	Specific viral variants not identified	
Ovine papillomavirus	Filiform squamous papillomas: young sheep on lower legs Fibropapillomas: adult sheep face, pinnae legs, teats	

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