Introduction

When dealing with dermatological diseases in livestock, a detailed history is critical to help establish a definitive diagnosis and effective management plan. This applies to animals kept as pets, such as goats and pigs, and to commercial herds and flocks kept for meat, milk and hair/fleece. The attending veterinarian’s detailed knowledge of the farm is a critical part of the history and will include the experience of previous disease outbreaks and an awareness of local risk factors for disease. This awareness may, in part, include monitoring of herd/flock health plans, previous disease investigations and response to previous treatment/management regimens. A comprehensive, holistic, approach to the management of the skin disease will inform the prognosis for the control or eradication of a disease and will help to manage the animal owner/keeper’s expectations.

To justify the prescription of parenteral antimicrobial agents for livestock species with skin infections, it is important to make a careful assessment of the case. It is appreciated that usually the history and clinical presentation may allow a provisional initial diagnosis based only on pattern recognition and the clinician’s experience. In some situations, such as those associated with large groups of affected animals (with high morbidity), or animals with chronic disease, it is important to take the time to undertake a thorough clinical examination before embarking on a poly-pharmacy approach to “rule out” causes of disease. This is particularly important where morbidity is high and the livestock of perceived high value to the keeper/owner, such as goats and small-breed pigs, or when the skin condition is long standing/chronic. Ideally, the management plan should sequentially clarify the role of microbial infection and then ectoparasites before considering less common allergic and autoimmune conditions. Skin cytology is an invaluable in-house diagnostic method that can support the findings of culture. Taking skin samples for histopathology and possibly culture may prove valuable once other diagnostic methods have been explored. Given the need to protect the use of parenteral antimicrobials, topical antimicrobial therapies can be deployed successfully. The repeated use of macrocyclic lactones (avermectins) must be balanced in terms of the risks of promoting anthelmintic resistance versus controlling or eradicating the ectoparasites that have, ideally, been specifically identified.
response to therapy, one should consider sampling skin for histology and possibly culture.\textsuperscript{1,2}

It might be cynically assumed that once dermatological case(s) have seemingly failed to respond to a macrocyclic lactone (avermectin) and antimicrobial therapies then other therapies should be trialed on the assumption that parasites and infection have been ruled out. When looking for ectoparasites, coat brushings, clumps of hair and fleece material can be examined macroscopically in a sealed clear plastic bag; motile lice and Psoroptes mites can be observed. When looking for mites, it is important to clip hair adjacent to alopecic, encrusted lesions and then take multiple superficial skin scrapings from several sites. Coat brushings and scrapings should be examined microscopically to definitively identify the parasite, if possible on the farm, at low power mounted in mineral oil (liquid paraffin) with a cover slip. Given the propensity for ectoparasites to be reduced in number and not necessarily eradicated after 1 treatment, it is important to evaluate the response to therapy after at least 2 treatments (2 to 3 weeks apart) because the eggs of lice and mites will hatch and progress the infestation. Ideally, one should assess the response to treatment over a period of 56 days, which covers 2 life cycles.\textsuperscript{3}

Once the role of infection and ectoparasites has been evaluated, only then should the investigation progress to consider hypersensitivity or rare immune-mediated skin conditions, which are not well described in livestock. Some individuals within a herd can be severely affected by mite infestation; this might suggest that such cases have some form of the allergic response to Chorioptes or Sarcoptes mites (notably in camels and goats) although the immunological basis has not been described in detail. In many situations, there are no licensed products for these species and it is critical to follow regulatory Food and Drug Administration (FDA) statutory guidance on milk and meat withdrawal. There are no FDA-registered products for skin problems in camels and goats, consequently, attending veterinarians must follow the Animal Medicinal Drug Use Clarification Act when considering extralabel drug use in these species, as well as for pigs and sheep when considering avermectins (AV) and other ectoparasiticides.

In the following sections, there is a focus on diagnostic methods and therapeutic interventions for selected topics. Standard texts reflect the substantial range of skin conditions seen in livestock.\textsuperscript{1,2,4-8}

**Alpacas and Ectoparasites**

South American camelids, namely alpacas and llamas, are susceptible to lice infestation (chewing and sucking) and various forms of mite infestation including, most commonly, Chorioptes sp and Sarcoptes sp, rarely Demodex sp and occasionally Psoroptes mite species.

**Scabies**

Camelids owners can have close contact with their animals when handling them. Sarcoptic mange, due to Sarcoptes scabiei, is of particular concern because it is potentially a zoonotic agent.\textsuperscript{9} Scabies can be associated with major disease outbreaks with a significant mortality rate.\textsuperscript{10-12} Coinfection with Sarcoptes and Chorioptes spp in alpacas has been reported.\textsuperscript{13} Lesions include papules and pustules with crusting. The distribution may include interdigital areas, medial thigh, ventral abdomen (Figure 1), thorax, axillae, perineum and prepuce. Chronic infestation may be associated with marked skin thickening and alopecia, although this presentation is nonspecific.\textsuperscript{14} Marked pruritus is usually a distinct feature, although some owners may not be aware of the severity of the self-trauma or assume their animals have chorioptic mange. It is not known why certain alpacas within a group seem more susceptible than others to developing signs of severe mite infestation. The remainder of the herd may have few, if any, signs of skin disease. Deaths have been associated with severe inanition due to severe chronic sarcoptic mange.\textsuperscript{15}

![Figure 1](image-url) — Thick crusts on the ventral abdomen of an emaciated 6-month-old cria with generalized sarcoptic mange that was assumed to have Chorioptes and that was found dead and submitted for postmortem examination.

The diagnosis of sarcoptic mange requires the detection of Sarcoptes mites, eggs or fecal pellets through skin scraping. Unlike other host species the number of mites can be high on some camels. Mites may even be seen on histological examination of skin biopsy samples. Even so, the diagnosis of sarcoptic mange may be supported by the detection of mites in histological sections; failure to find them in
histological sections does not rule scabies out. It is not recommended to use the response to treatment as a diagnostic tool (although it is very important when dealing with dogs with suspected scabies). To eradicate sarcoptic mange, one should consider treating all of the animals in the group over a period of 2 mite life cycles, at least 6 weeks. Camelids respond poorly to treatment, and it may take longer for signs of infestation to resolve and for mites to disappear on scrapes used to monitor response to treatment. There are no licensed products for the treatment of ectoparasites in camelids. Various AVs have been reported. Products administered per os or topically are less likely to be effective than injectable. Some reports include dual product use with an AV and amitraz. Several studies have reported that alpacas and llamas have low blood levels of AVs compared with farmed ruminants; this may be due to differences in drug metabolism and or absorption. This may be partly due to differences in skin lipids.

One treatment regimen is the administration of an ivermectin-containing product subcutaneously. The recommended dose, 400 μg/kg (assuming they can be weighed accurately) administered every 2 weeks for 3 doses, is empirically 2 times the standard dose of 200 μg/kg used in other species. The use of AVs for ectoparasites must consider the potential for impact on gut endoparasite resistance. Given the severity of the skin condition in some individuals and the potential for zoonotic spread, treatment of Sarcoptes mites should be implemented. Ongoing monitoring of fecal samples for endoparasites is recommended.

Chorioptic mange

Chorioptic mange in camelids can have a similar presentation to sarcoptic mange in terms of lesion distribution, with a lower level of pruritus. Areas with mild alopecia and scaling of the interdigital areas (Figure 2) are useful to look for mites (through skin scraping). Treatment can be challenging because Chorioptes mites do not burrow and mites may survive up to 3 weeks off the host, and most of a herd can be mildly infested (carrier status). While the factors for the management of scabies apply, there are additional factors with Chorioptes mites. Careful cleaning of housing with bedding material removal may help reduce the mite burden. Topical therapies are often deployed simultaneously with AVs and have included fipronil, selenium sulfide washes and lime sulfur dips.

Studies of healthy and skin-diseased alpacas (especially with chorioptic mange) have reported serum and plasma zinc concentrations (alpaca, 3 to 14.6 μmol/L) that are low when compared with sheep (12 to 14 μmol/L), cattle (15 to 27 μmol/L), and goats (8.7 to 9.6 μmol/L). While it is possible to observe responses to zinc supplementation in alpacas with chronic skin disease, this does not necessarily mean that deficiency is a primary factor. Furthermore, concurrent parasitic and infectious causes of skin disease should always be considered when subnormal blood values for trace elements are reported. Owners are often keen to trial supplementation with trace elements, although camelids are normally fed some supplementary concentrate and are unlikely to be zinc deficient. Consequently, careful assessment of the response to multiple interventions, including zinc supplementation, should be undertaken before making a diagnosis of zinc-responsive dermatosis.

Reindeer

There is an unusual condition involving hyperplasia of antler velvet that can lead to enormous heavy growths on various parts of the antlers (Figure 3). Historically lesions were first described by Anton Bubenik back in 1966. The condition seems to be reported only in the United Kingdom with no formal published accounts elsewhere. This is seen only in castrated males and occasionally sexually intact males. The underlying antler bone is normal and the velvet will eventually be shed, although the timing of this process can be delayed in castrated males. Lesions may recur year after year in some individuals. Lesions may become infected with bacteria and fly struck, thus necessitating amputation of part of or the whole of the antler. There is no evidence of a viral or neoplastic etiology. These soft tissue velvet lesions must be distinguished from the bony antler lesions seen in some roe and fallow deer sometimes termed osteoma, antleroma or perruque, which all are seen in castrated males.
Given that the cycle of antler development in reindeer will be influenced by hormonal factors, owners will often ask veterinarians to administer hormones to their reindeer to influence the duration of the period that antlers are in velvet to promote antler casting or to treat the hyperplastic velvet condition. There is no good-quality published evidence that hormone intervention in castrated reindeer has any effect on antler development, casting or the hyperplastic condition.\(^{25}\)

Goats

Goats are kept for fiber, meat, milk and in pet farm/zoological collections (popular breeds include pygmy and Nigerian dwarf). Some owners treat them as pets allowing them to be in the home and will undertake long-term therapeutic interventions for chronic skin disease.\(^{27}\)

As in camels, goats are susceptible to a variety of ectoparasites including lice and mites, with Chorioptes mites being particularly common.\(^{2}\) Mites reside on the distal limbs, especially around the patterns (Figure 4). The diagnosis can be achieved with a microscopic examination of multiple skin scrapes as given above.

The management of chorioptic mange in goats can be challenging. In dairy units, group sizes can be large and treating the whole group can be difficult; it may be worth culling severely affected animals. Since they are often housed, it is more likely that environmental contamination can be managed although the main burden of infestation will be residing on animals with no overt signs of disease.\(^{27}\) Topical therapies can complement the systemic use of AVs. Historically these have been reported to include amitraz, fipronil, lime sulfur dips and selenium sulfide washes. In Europe, eprinomectin is licensed for use in dairy goats with no requirement for milk withdrawal.\(^{28}\) Adverse events with the use of AVs in goats are rare. One case report\(^{29}\) described neurological signs in a Thuringian goat within hours of receiving a subcutaneous dose of doramectin. DNA sequencing suggested the potential for mutations in the multiple drug resistance gene \(mdr1\) that may lead to the accumulation of AVs in the central nervous system of some goats.\(^{29}\)

In goats, the topical use of AVs may be associated with variable absorption, which may be breed related and reflect the metabolic status of the goat, the amount of subcutaneous fat, and, perhaps, the variations in degradation of the AV in the skin. As in camels, there is an assumption that double dosing is required with AVs compared with other ruminants (whichever route of administration) and that repeated dosing is given over the period of 2 parasite life cycles (at least 6 weeks). Concerns remain on the impact of AVs on the environment including dung fauna and aquatic life, as well as the potential for promoting endoparasite resistance. Alternative parasiticides include permethrin-based products which may be used as an aid in the control of ectoparasites in goats.

Pemphigus foliaceus

Few autoimmune skin conditions are recognized in livestock, with the exception of pemphigus foliaceus (PF) in the goat.\(^{30}\) The main presenting signs of PF include a generalized severe pustular eruption involving most body areas. Pustules are transient and associated with marked crusting and multifocal alopecia. Pruritus can be a major problem. Pustular lesions may vary in number and location with waves of lesions developing and receding (Figure 5).

Cytology can be a quick in-house method to support the diagnosis (Figure 6). Staining of pustular material smeared onto a microscope slide for Romanowsky staining will reveal large numbers of acantholytic keratinocytes (keratinocytes with a nucleus which demonstrates that the cells have...
been released prematurely from the epidermis) admixed with numerous neutrophils and sometimes eosinophils. While secondary microbial infection can complicate the cytological picture, PF is a sterile pustular lesion and there should be no bacteria associated with the polymorphonuclear cells. Secondary bacterial overgrowth can be confusing so look for bacteria engulfed within the cells before electing to treat the infection. Given signs will wax and wane, there may seem to be a response to chlorhexidine soaks, but they are only dealing with the secondary infection. The definitive diagnosis requires histopathology, which reveals intraepidermal and/or intrafollicular pustules with abundant acantholytic keratinocytes in the granular or upper spinous cell layers. Pustules should be swabbed for microbial culture, while hairs and crusts can be collected for dermatophyte culture.

The mainstay of PF treatment has been glucocorticoids by injection. In most cases, there is no obvious trigger for the skin condition. The disease will require long-term intervention. Normally livestock species do not receive long-term steroid therapy. Adverse metabolic effects of such therapies are not well recorded in goats.

There are various creams, gels, ointments and sprays that contain glucocorticoids licensed for veterinary use. They do not seem to be effective in goats with PF.

Oral prednisolone has anecdotally been reported to be effective for pygmy goats with alopecic, exfoliative dermatitis (also known as pygmy goat seborrhoeic dermatitis and psoriasiform dermatitis). It may also be worth using in goats with PF. Doses of oral prednisolone can start at 1 to 2 mg/kg per day and then move to alternate-day dosing.21

Case reports of caprine PF have described using dexamethasone injections, usually subcutaneously, on a daily basis at 0.2 to 0.4 mg/kg per day, until some level of remission is observed. It could be argued that long-term utilization of injectable (or oral) steroids should aim for an alternate-day regimen (every second or third day when using dexamethasone salts) with the minimal effective dose. Injectable (long-acting) methylprednisolone acetate (2 mg/kg initial dose) can be given every 2 to 3 weeks to manage some cases. If fixed periods are used to inject a long-acting steroid, then incremental reductions in the injected dose may see the skin condition under control while aiming for the minimal effective dose. Owners can be trained to administer the subcutaneous injections.

Long-term steroid therapy for PF may be associated with fatal consequences presumed to be due to opportunistic bacterial and viral infection due to immune suppression.30 A case of erythema multiforme was reported in a Nubian goat; a short course of daily dexamethasone injections was associated
with presumed immune suppression associated with mycotic abomasitis and hepatic abscession.  

It is important to appreciate that the signs of caprine PF only need to be controlled, not necessarily completely eliminated. Owners should be advised of the risk of adverse events associated with long-term glucocorticoid administration.

Regular bathing can be useful for removing crust material and may periodically be combined with systemic antibacterial agents where there is evidence of secondary microbial infection.

As in camellads, wills empirically administer zinc supplements for skin conditions even though zinc deficiency is rare and goats routinely receive concentrate feeds rich in zinc. Supplementation is unlikely to be harmful and may support the management of a skin condition.

**Pigs**

**Sarcoptic mange**

Mange in pigs due to *S scabiei* is a well-recognized problem in commercial pigs. Pigs usually show pruritic behavior, and in early stages there can be a generalized papular eruption associated with a hypersensitivity response (Supplementary Figure S1). In time, this may be followed by a more chronic presentation where there are thick crustations and scale, especially on the pinnae, which may extend to the body (Supplementary Figure S2). In pet pigs (pot-bellied and minibreds), owners may not routinely use AV anthelmintics. Consequently, they may have an increased risk for scabies. Given the zoonotic potential, it is important to rule out mites when dealing with skin conditions in pet pigs.  

Superficial skin scrapings and maceration of encrustations and ceruminous material from the pinnae and ear canal can be used to look microscopically for mites, eggs and fecal pellets (Supplementary Figure S3). If infestation is suspected and mites are not detected, then trial treatment should be implemented.

There is an experimental model of human scabies where pigs are given repeated injections of dexamethasone and exposed to *Sarcoptes scabiei* mites. Some pigs will develop an enormous burden of mites, similar to encrusted scabies in humans. Treatment of porcine scabies often relies on the use of licensed products such as ivermectin. The model has enabled an assessment of treating infected pigs with afoxolaner. One oral dose seemingly cleared infestation rapidly. Since such drugs are not routinely licensed for use in the pig the attending veterinarian may wish to use AVs. It is important to administer them correctly. In 1 case report, it was suspected that oral ivermectin had not been effective because the pig may have not received the whole dose; afoxolaner was used with a rapid response.

**Demodectic mange**

Demodectic mange in pigs due to *Demodex phylloides* has rarely been described as a major problem in pigs. It is presumed to be a commensal mite. Clinical disease is likely when the host is immune suppressed in some way and or in poor body condition. The clinical presentation can be similar to sarcoptic mange albeit with a lower pruritus score (Supplementary Figure S4). Clinical examination may reveal hair loss, erythema, papulocrusting lesions on the head, snout and eyelids, with extension to the ventral trunk and medial thighs. In time, clinical lesions may include hyperkeratotic comedones/nodules packed with *Demodex* mites and a caseous exudate suggestive of swinepox. Pig pet owners may need to be advised on the different forms of mange (scabies versus demodicosis).

Mites can be found with microscopic examination of skin scrapings and hair plucks or material from the incision of nodules. When treating porcine demodicosis, one should address underlying disease(s)/factors that enable the mite to thrive. Historically amitraz and lime sulfur dips have been recommended. It may be the case that, as in dogs with *Demodex*, pigs will respond to isoxazoline-based products such as afoxolaner.

**Sheep and Insect Bite (Culicoides) Hypersensitivity**

Hypersensitivity reactions to presumed *Culicoides* allergens presented to sheep (also goats and alpacas) have been recognized for many years wherever there are such midges. Ovine cases are usually sporadic although in some flocks up to 40% of ewes may be affected. A key historical feature is a seasonal recurrence, year after year, in some individuals. Skin lesions are associated with pruritus which is typically apparent from spring to the summer months when midges are particularly active. The nonwool areas of the body are affected including the ventral trunk, head (including the periorcular, peribuccal and nasal regions, and the inner and outer aspects of the pinnae), medial aspect of the legs, udder and teats. Lesions observed may vary from small crusts to marked thickening of the skin with ulceration and crust formation. Pruritus may manifest as foot stamping and dropping to the ground and sternal recumbency.

The diagnosis is based in part on the history and clinical presentation. Supportive evidence may include the histopathological findings in skin biopsy samples that are consistent with an allergic response to ectoparasite activity, although in themselves they do not establish hard evidence for an allergic disease process. There are no serological methods that can be applied to livestock for the detection of allergen-specific IgE. Several studies reported the results of intradermal tests with *Culicoides* antigens. These are not formally validated diagnostic tests and the antigens are not standardized for any species. In livestock, they merely act as supporting evidence. One can also see peripheral eosinophilia with routine hematology.

Management of this condition, as in other species, should rely on trying to reduce exposure including housing affected animals when the insect activity is most likely, particularly from before dusk to after...
dawn. Regular application of topical insecticides and repellents may be useful adjunct measures.

Treatment may include topical and systemic (injectable) glucocorticoids. Some cases may have secondary microbial infection and supportive therapies may include chlorhexidine-based soaks and injectable antimicrobial agents as required.

In a commercial flock, it may be best to cull affected ewes although the genetic basis for the condition is not well established.

**Poxviruses**

Sheep and goats infected with parapox virus (also known as orf, contagious viral pustular dermatitis and contagious ecthyma) present with lesions involving the head, udder and limbs. The virus may survive months in the environment and some animals may be subclinical carriers. Viral transmission may be facilitated by biting insects. Signs of infection are presumed to follow damage to the skin due to rough grazing including thistles or coarse straw. Intraoral lesions may be ulcerative and confused with foot and mouth virus. Careful examination of the mucocutaneous junctions and skin may reveal hyperplastic encrusted lesions more typical of orf. Encrustation and thickening of the skin around the muzzle may be associated with nasal exudate and in some cases swelling of the head, which may be confused with Blueteugue Virus infection (Supplementary Figure S8). Orf may be complicated by secondary infection including staphylococci and *Dermatophilus* sp (Strawberry foot rot). The course of infection may be relatively short with sheep recovering over several weeks. A persistent (atypical) form, with widespread lesions that may be papillomatous, may take months to clear from individuals in a flock. There are occasional reports of sheep that do not seem to clear infection, that make a serological response and that do not have the typical T-cell-driven immune response suggesting some form of immune deficiency. Several flocks of Scottish Black face sheep may have a genetic factor contributing to the poor immune response observed in 2- to 14-month-old lambs with extensive lesions and no obvious lymphadenomegaly.

The diagnosis of orf is a good example of establishing a definitive diagnosis based on the deployment of diagnostic methods. The diagnosis is often made empirically from the clinical presentation. Crust material can be examined by electron microscopy and PCR to detect the virus. Since haired skin is affected dermatophytosis should be considered. Skin scrapes should be examined microscopically to help rule out ectoparasites (*Choriopotes, Psoroptes,* and *Sarcopotes* spp). Sampling skin lesions for histopathology may be useful to establish a diagnosis, especially when hyperplastic papilliform lesions are present. If morbidity is high and there are systemic signs then consideration may be given to notifiable capripoxvirus infections (sheep and goat pox).

Camelids may, uncommonly, be infected with parapoxvirus with lesions especially seen on the mucocutaneous areas with ulceration, crustling, and some thickening of the skin, usually around the mouth; there are also reports of orthopoxvirus infection in alpacas which may present with multifocal discrete poxvirus lesions over the whole body. Deer, including reindeer, are susceptible to orf, although they have their own poxviruses associated with skin lesions in mule deer and white tail deer.

**Summary**

Skin diseases in livestock species may be associated with low mortality and high morbidity. While economic factors may potentially have a negative impact on the investigation and management of skin diseases, it is important to adopt a systematic approach drawing on the history, thorough clinical examination and assessment of the findings of relevant diagnostic tests. Establishing a definitive diagnosis is critical for implementing an effective management plan, especially when extralabel drug use is being considered.

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**References**


**Supplementary Materials**

Supplementary materials are posted online at the journal website: avmajournals.avma.org.

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**Featured article from AJVR**

**Evaluation of canine adipose-derived multipotent stromal cell differentiation to ligamentoblasts on tensioned collagen type I templates in a custom bioreactor culture system**

*Takashi Taguchi, Nan Zhang, Dominique Angibeau, et al*

Ligamentogenic medium was superior to stromal medium for differentiation of adipose-derived multipotent stem cells to ligamentoblasts on suture-augmented collagen type I scaffolds. Customized ligament neotissue may augment treatment options for dogs with cranial cruciate ligament rupture.

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