Some important Ectoparasites of Alpaca (*Vicugna pacos*) and Llama (*Lama glama*)

Set Bornstein[1]* and Kerstin de Verdier[2]

[1]Department of Virology, Immunobiology and Parasitology, National Veterinary Institute, Sweden
[2]Department of Animal Health and Antimicrobial Strategies, National Veterinary Institute, Sweden

Abstract

The most important ectoparasites infesting/infecting alpaca (*Vicugna pacos*) and llama (*Lama glama*) are reviewed. The clinical manifestation and the diagnosis of the different parasitic infections/infestations of *Sarcoptes scabiei*, *Chorioptes* sp., *Psoroptes* sp., *Damalinia* (Bovicola) breviceps and *Microthoracius* spp. are described as well as therapies against them. Demonstrating *S. scabiei* and *Chorioptes* sp. with available diagnostic methods are challengingly often due to the relatively small numbers of mites that may elicit clinical disease. In *Chorioptes* sp. infestations it has been shown that alpacas are often subclinically infested. Predilection places are between the toes and in the axillae. The variable response to modern acaricidal treatments emphazises the need of more evidence based studies. The lack of lanolin in the fibres of South American camelids may explain the poor response to topical applications of modern insecticidal/acaricidal products used on other animals. Pharmacokinetic studies of such substances are limited. Few products are licenced although several products that are used and are available for other animals are used off-label. Applying a combination of systemic and topical treatments may produce optimal results. The need to apply treatments against the mange mites more frequently and with higher dosages of some of the acaricidal substances than recommended for other livestock is indicated. Lice infestations are often easier to deal with. Systemic treatment should be applied against suckling lice and topical against the biting lice. All animals in affected herds should be treated at the same time and stringent biosecurity measures following treatment is recommended to avoid re-infections/infestations.

Key words: alpaca, llama, mange, mites, lice.

* Corresponding author: Email: set.bornstein@telia.com

1. Introduction

Increasing numbers of South American Camelids (SACs), particularly alpaca (*Vicugna pacos*) and llama (*Lama glama*) are being imported to various countries outside of South America including Europe, for wool (fibre) production, breeding, and as pack- and companion animals. Some families of llama males are sought after as guard animals protecting sheep and goats against predators. During the nineteenth century few SACs were exported from South America to other countries and then mainly as zoo animals. Exports were banned by Andean countries from the middle of the nineteenth century until larger exports from Chile were started in 1983-84, first to North America (Hoffman, 2003).

1.1. Ectoparasites

Like other livestock alpacas and llamas are exposed to and affected by a range of ectoparasites (Rosychuk, 1994, Bornstein, 2002) (Table 1). Of particular importance are the mange mites; the burrowing *Sarcoptes scabiei*, the non-burrowing *Chorioptes* sp. and *Psoroptes* sp. as well as the lice; the biting louse *Damalinia (Bovicola) breviceps* and sucking lice (*Microthoracius* spp.) (Ballweber, 2009). Several miscellaneous flies, the same species that plague other lifestock, also affect SACs (Table 1). Some ectoparasites (e.g. some bot flies and ticks) are of regional importance (Fowler, 1998, Ballweber, 2009).

Table 1. Ectoparasites infecting/infesting alpaca and llama belonging to the Phylum, Arthropoda.

Order	Family	Species	Disease
Astigmata	Sarcoptidae	*Sarcoptes scabiei*	sarcoptic mange
	Psoroptidae	*Chorioptes* sp	chorioptic mange
		Psoroptes sp	psoroptic mange (ear canker)
Prostigmata	Demodicidae	*Demodex* sp[1]	demodectic mange
	Trombiculidae	*Eutrombicula* sp	trombiculosis
Metastigmata	Argasida (Soft ticks)		
		Otobius mengnini[2]	otitis
	Ixodidae (Hard ticks)[3]		
		Ixodes holocyclus[4]	Tick paralysis
		Dermacentor spp[5]	Tick paralysis & toxicosis
		Amblyomma sp[6]	
Phthiraptera	Sucking lice[7]	*Microthoracius* spp	
	Biting lice[8]	***Bovicola breviceps***	**Pediculosis**
Siphonaptera	Flees	*Vermipsylla* sp	
Diptera (flies)			
	Culicidae (mosquitos)		
	Simulidae (black flies)		
	Tabanidae	*Tabanus* spp (horse flies, deer fly)	
	Muscidae	*Musca domestica* (house fly)	
		M autumnalis (face fly)	
		Stomoxys calcitrans (biting stable fly)	
		Hydrotea spp	
		Haematobia spp	
	Sarcophagidae		
	Calliphoridae (blowflies)	*Calliphora* sp	
		Cochliomyia hominivorax (primary screw worm)	
		Phaenicia spp (green blow fly)	
		Phormia spp (black blow fly)	
	Oestridae (Bot flies)		
		Oestrus ovis (Sheep nasal bot fly)	
		Cephenomyia sp[9] (Deer nasopharyngeal bot fly)	

[1]Infestations with *Demodex* spp rarely reported in SACs.
[2]Commonly infest llamas and alpacas in parts of western United States (Fowler, 1998, Ballweber, 2009).
[3]Alpacas and llamas worldwide are at risk to be infested by native ticks e.g. by various *Ixodidae* many that are known vectors of pathogens.
[4]*Ixodes holocyclus* causes severe tick paralysis in Australia (Jonsson and Rozmanec, 1997).
[5]Tick paralysis caused by *Dermacentor Andersoni* (Barrington and Parish., 1995) and *Dermacentor* sp. in llamas has been reported from the US (Cebra et al., 1996)
[6]*Windsor* et al., 1992) report of occasional findings.
[7]Suborder; Anoplura
[8]Suborder; Mallophaga, *Bovicola* (*Damalinia*) *breviceps* a common finding in alpacas in Australia and New Zealand.
[9]*Cephenomyia* sp (parasite of deer) has been found in llamas in western US (Fowler, 1998, Ballweber, 2009).

The mange mites have been reported to be common infestations on alpacas and llamas, also in countries outside of South America. Problems with mange are reported frequently from several countries in Europe (Petrikowski, 1998, Tait et al., 2002, Geurden et al., 2003, D`Alterio et al., 2006, Lau et al., 2007, Twomey et al., 2009). In the UK e.g. 23% of alpaca owners were concerned about mange in their animals (Tait et al., 2002), and 52.1% of alpaca herds and 14% of llama herds were reported to have mange in the UK in 2007 (Lusat et al., 2009). Amongst the confirmed diagnosis reported in the latter retrospective postal questionnaire study (Lusat et al., 2009) most cases of mange were chorioptic and sarcoptic and relatively few were psoroptic mange. In Switzerland alpaca owners regarded mange as one of the four most frequent health problems (Burri et al., 2005). In Sweden 44% of alpaca breeders, responding to a postal questionnaire study with response rate of 80%, reported that skin disease was their biggest concern affecting their alpaca herds (de Verdier and Bornstein, 2010). Mange type lesions were among the dominant signs reported.

Sarcoptes scabiei var. *aucheniae* was previously considered to be very prevalent in SACs in South America (Alvarado et al., 1966). It was said to be responsible for 95% of all economic losses due to ectoparasites in South America, alpacas being infected up to 40% and llamas up to 25% (Leguia, 1991). Infestations with *Chorioptes* sp. are also very common. Some authors even regard *Chorioptes* sp. mites as the most common ectoparasite infesting SACs (D`Alterio et al., 2005a). It appears that chorioptic mange is more common outside of South America (Ballweber, 2009) and is particularly prevalent in Europe. The mite is assumed to be *C. bovis* (Fowler, 1998, Foster et al., 2007). *Psoroptes (aucheniae) ovis*[1] may also be found to infest particularly the external ears (pinnae) and the external ear canals. Mixed infections occur with two and even three of the mite species (Curtis et al., 2001, Geurden et al., 2003, Leroy et al., 2003, Borgesteede et al., 2006, Foster et al., 2007).

The lice; the biting louse *Damalinia (Bovicola) breviceps* and sucking lice (*Microthoracius* spp.) are commonly found infesting SACs in South America. The biting louse is particularly prevalent in South America, Australia and New Zealand (Palma et al., 2006, Vaughan, 2004).

1.2. Mange mites

Sarcoptes scabiei (Figure 1) is recognized by the characteristic oval, ventrally flattened and dorsally convex tortoise-like body, which is covered with fine striations. The male is approximately two thirds the size of the female, which is 0.3-0.5 mm long by 0.23-0.42 mm wide (Fain, 1968). The short anterior legs extend beyond the anterior-lateral margins of the front part of the body while the posterior legs do not extend beyond the lateral body margins. In both females and males the two front legs terminate in a stalked empodium or pulvillus (sucker) borne on a long stalk-like pretarsus.

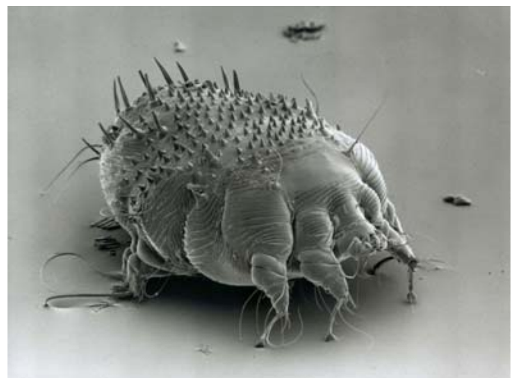

Figure 1. *Sarcoptes scabiei* SEM image of a female adult mite (photo: T. Nikkilä/S. Bornstein).

Chorioptes spp. (Figure 2) resemble *Psoroptes* mites. (Figure 3) except for being significantly shorter in size. Adult female *Chorioptes* spp. are approximately 0.3 mm in length, they have shorter and rounded mouthparts and their tarsal suckers are cup-shaped and placed on short, unsegmented pedicels (pretarsi) on the first, second and fourth pair of legs. The fourth pair of legs has long and slender tarsi. The males have truncate abdominal tubercles (Wall and Shearer, 2001).

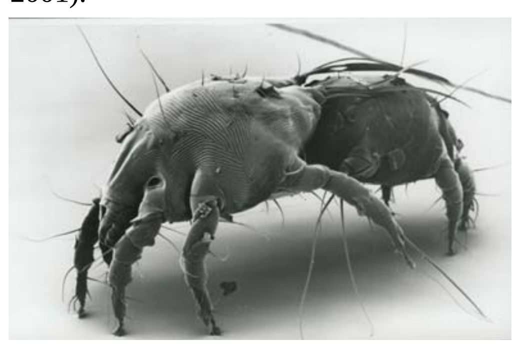

Figure 2. Mating pair of *Chorioptes* sp. (SEM, photo: T. Nikkilä/S. Bornstein).

[1] D´Alterio GL., Batty A., Laxon K., Duffus P., 2001. *Psoroptes* species in alpacas. Vet Rec., 149, 96.

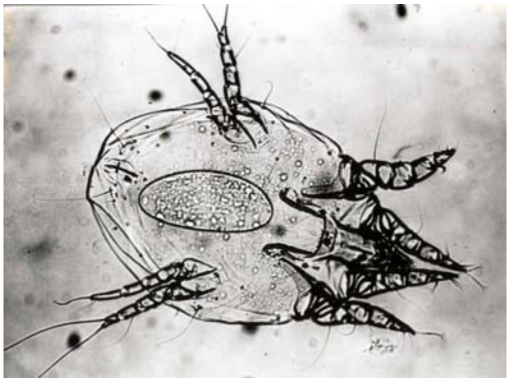

Figure 3. *Psoroptes ovis* (photo R Wall, Univ of Bristol, UK).

Adult *Psoroptes* males can reach a length of 0.7 mm and the female 0.8 mm. and are identified by the three segmented pedicles and funnel shaped suckers that are present on the first, second and fourth pair of legs. These three segmented pedicles are highly diagnostic features. Two long whip-like setae are present on the third pair of legs. The mouthparts are pointed and the males have rounded abdominal tubercles. The smaller adult males are recognizable by their copulatory suckers and paired posterior lobes. They also have pulvilli on the three pairs of legs and setae on the fourth pair of legs. All the four legs of the adult female are approximately of the same length, whereas in males the fourth pair is extremely short (Wall and Shearer, 2001).

1.3. Life cycles

The life cycles of mange mites differ in particularly two mayor aspect. *Sarcoptes scabiei*, are known to parasitize more than 100 different animal species (Bornstein et al., 2001) and belong to the `burrowing` mites. *Chorioptes* and *Psoroptes* spp are `non burrowing` mites. All life stages of *S. scabiei*, larva, protonymps, tritonymphs and adults can penetrate the skin surface into the epidermis where they form tunnels. Fertilized adult females, with a life expectancy of 4-6 weeks, lay eggs in the tunnels at a rate of 3-4/day. The eggs hatch within 3 days, and larvae that have three pairs of legs emerge. In the original tunnels or their extensions the larvae develop into first nymphal stage (protonymph) in 3-4 days and into a second nymphal stage (tritonymph) about 3 days later. Another 2-4 days are required before the tritonymph molts into adults (Bornstein et al., 2001). Nymphs and adults have four pair of legs. Apart from living in the tunnels excavated in the epithelium all the life stages can wander on the skin (thus occasionally being dislodged from the host). The mites are highly mobile, despite their short legs, may move up to 2.5 cm/min (Wall and Shearer, 2001). The duration of the life cycle of *S. scabiei* appears to vary between 12-21 days on the different hosts studied (Bornstein, 1995).

Chorioptes and *Psoroptes* mites in general spend their entire life on the skin of their infested host (if not detached from the body, often along with fibre/wool). Their life cycles are similar. Females lay eggs on the surface of the skin. The eggs hatch three-legged larvae (within 3-4 days) that subsequently develop through two nymphal stages (four-legged) before developing into either females or male adult mites. The larvae feed and moult after 2-3 days to the first nymphal stage (protonymph) that lasts about 3-4 days before the next moult occurs to the tritonymph (deutonymph).

Egg-laying *Chorioptes* females may live up to 3 weeks during which time they produce 17 eggs in average. Adult males may live 7-8 weeks. Off the host the mites may live up to 3 weeks (Wall and Shearer, 2001), according to Scott and Miller (2003) up to 70 days, allowing transmission by fomites, housing and bedding etc. However, the main way of transmission is considered to be direct.

The life-cycle from egg to egg is about 12 days for *Psoroptes* sp. (Soulsby, 1982). According to Wall and Shearer (1997) the minimum duration is about 14 days. However, according to Fowler (1998) this depends on where the eggs of the *Psoroptes* sp. are. If they have been separated from direct contact with the skin by e.g. crusts, hatching may be delayed for 4-5 days. If the eggs have become detached from the body, hatching may take 10 days or fail altogether (Fowler, 1998). The female lays 1-3 eggs per day and during her life time of 40-60 days (average 16 days), she may lay between 40-100 eggs, average about 40 - 50 (Wall and Shearer, 1997, 2001). The egg-laying rate varies with the age of the mite. Not all eggs will survive.

Survival time off the host depends strongly on the ambient temperature and humidity. At low temperatures (<15^0C) and at a relatively high humidity (>75%) *Psoroptes* mites may survive more than 18 days. This may have an important impact on transmission from the environment to new hosts via fomites, bedding, clothing, grooming tools, areas of dust bathing etc. As with the other mange mites transmission is primarily through direct contact (Fowler 1989, Ballweber, 2009).

The life cycles described above all derive from studies made on infected/infested animals other than SACs.

Chorioptes mites feed only superficially with mouthparts adapted to chew and cannot penetrate the skin. They feed on scales and other debris shed. The mouthparts of *Psoroptes* mites are adapted for sucking and the mites are believed to ingest the lipid emulsions of lymph, skin cells, skin secretions and bacteria on the skin surface (Wall and Shearer, 2001).

It was earlier believed that *Psoroptes* spp. were host specific, i.e. each particular host species had its own *Psoroptes* sp. According to Zahler et al., (1998) there is only one species (*P. ovis*) as is the case with *S. scabiei*, but for convenience some authors still prefer to separate *P. ovis*, the body mite of sheep causing sheep scab from *P. cuniculi*, the ear mite of rabbits (Wall and Shearer, 2001).

The taxonomic status of *Chorioptes* is also unclear. Two species, *C. bovis* Hering, 1845 and *C. texanus* Hirst, 1924 are generally accepted (Sweatman, 1957, Yeruham et al., 1999), based on morphology and genetic differentiation. These mites are of veterinary interest. Three other `species` infesting wildlife are questionable (Hestvik et al., 2007, Lusat et al., 2011). There are indications that the Chorioptes sp. infesting the outer ear canals of moose (Alces alces) is a species of its own (Hestvik et al., 2007).

1.4. Mange

Sarcoptic mange

The early acute manifestations of sarcoptic mange include mild to severe pruritus with erythema, papules and pustules, soon developing to crusting, alopecia and later to lichenification and thickening of the skin, the chronic stage. In some infected hosts the acute phase is shown to be due to a hypersensitivity reaction elicited by the host to antigenic/allergic material, including components of faeces from the mites (Bornstein, 1995). The hypersensitivity causes inflammation, pruritus, surface exudation, scale and crust formation and excoriations due to self-trauma (pruritus/scratching) Lesions may be seen on the limbs (often between the toes), medial thighs, ventral abdomen (Figure 4), chest, axillae, perineum, prepuce and the head, including the lips and ears. Fibre-free areas are said to be more often affected. Damage to the fibre and loss of condition occur. In very severe infections the disease may result in death (Borgesteede et al., 2006, Twomey et al., 2009). There are historical accounts of large epidemics of *S. scabiei* var. *aucheniae* affecting SACs in South America (during 1544, 1545, 1548, 1826, 1836 and 1839) causing havoc in SACs with mortalities of over two thirds of the populations (Alvarado et al., 1966)**.**

Figure 4. Extensive lesions on the abdomen including the scrotum of an alpaca with skin disease of unknown cause. Erythema, papules, pustules, alopecia, crusting, lichenification and thickening of the skin (hyperkeratosis) are seen. Skin lesions as these are often seen in infections by *Sarcoptes scabiei* and infestations with *Chorioptes* sp, respectively. No mites were found. The diagnosis supported by histology was `ìdiopathic hyperkeratosis` (Photo AP Foster, case material from the Univ. of Bristol, UK).

About 20 years ago there was a 20-40 % prevalence of the infection among the alpaca in peasant communities in the Andes (Leguia, 1991). The earlier high prevalence of the infection seen in the alpacas and llamas imported and bred in the US has been substantially reduced, most probably due to the frequent use of ivermectin (Rosychuk, 1989). A similar situation is seen presently in many herds in e.g. Peru. In Europe there are several case reports, some describing widespread infections within individual herds (Curtis et al., 2001, Leroy et al., 2003, Borgesteede, 2006, Lau et al., 2007, Twomey et al., 2009). However, there is no proper study addressing the prevalence of sarcoptic mange.

Chorioptic mange

Previously *Chorioptes* sp. infestations were considered relatively rare in SACs (Rosychuk, 1989, Fowler, 1998), although Cremers (1985) was of the opposite opinion. Today, chorioptic mange is a very common condition in many herds worldwide, particularly among alpacas (D´Alteiro et al., 2005a, Plant et al., 2007). Clinical signs of chorioptic mange may mimic sarcoptic mange, but animals affected usually exhibit a milder pruritus and sometimes none at all (subclinical). Individuals with a heavy infestation may be free of any clinical signs of mange although others in the same herd with lower infestations may show severe extensive skin lesions (Plant et al., 2007). Often alopecia and scaling are seen on the feet. Often, as in sarcoptic mange, it is found between the toes (Figure 5) and the base of the tail. Lesions may spread to the ventral abdomen, medial limbs and often the ears. Lichenification and hyperpigmentation (greying of the skin) develop in chronic cases.

The acute phase of the infestation might be due to a hypersensitivity reaction to the mites as is thought to be the case in the hosts reaction to *Psoroptes* sp. infestations as well as against *S. scabiei* infections (Wall and Shearer, 2001).

Figure 5. Mange between the front toes (interdigital area) of an alpaca infested with *Chorioptes* sp., exhibiting alopecia, scaling, heavy crusting (hyperkeratosis). Similar lesions may be seen in *S. scabiei* infections (Photo AP Foster, Univ. of Bristol, UK)

Psoroptic mange

Psoroptic mange in SACs is often seen at predilection sites; pinnae and external ear canals, as erythema, crusting, papules, serum exudates and alopecia. Pruritus is evident emanating from these lesions. Typical lesions seen in the external ear canals are big flakes. Exudate occasionally appears, which is most likely due to secondary infections. Ears and parotid regions may sometimes become grossly swollen (Alvarado et al., 1966). However, lesions as well as pruritus may be generalised with or without involvement of the external ear canal. Other sites with lesions reported include nares, axillae, groin, neck, legs, abdomen, perineum, shoulders, back and its sides and the base of the tail (Foster et al., 2007). Intermittent bilateral ear twitching and head shaking may indicate otitis due to *Psoroptes* sp. infestations.

The *Psoroptes* sp. of alpacas and llamas has previously been referred to as *P. auchenia* or *P. communis auchinae*[2], but adequate identifications of the different isolates of the mites have not yet been done (Bates, 1999). The first report of psoroptic mange in llamas outside of

South America was in the US in 1992 (Foreyt et al., 1992), and in alpacas a decade later in UK (see page 2[1]).

1.5. Cross-transmission

The possibility of cross-transmission of any of the mange mites and some other ectoparasites (like ticks, bot flies) from alpacas and llamas to domestic sheep and other livestock and vice versa is a concern (Foster et al., 2007).

Sarcoptes scabiei var. *aucheniae* was reported to be able to infect sheep and horses (Neveu-Lemaire, 1952). Another *S. scabiei* variant (var. *cameli),* a common pathogen in dromedaries (*Camelus dromedarius*), was shown experimentally to be able to infect sheep and goats (Nayel and Abu-Samra, 1986a), and *S. scabiei* derived from goats and sheep readily infected dromedaries experimentally **(**Nayel and Abu-Samra, 1986b). Some variants of *S. scabiei* are known to cross-infect humans resulting in scabies-like symptoms (Arlian, 1989, Fain, 1978). Such infections are generally self-limiting. There are occasional reports of severe chronic `scabies` derived from infected domestic animals[3].

Successful experimental and natural infections of humans with *S. scabiei* from alpacas have been reported (Mellanby, 1946-47, Foster et al., 2007, Twomey et al., 2009), indicating the zoonotic potential *of S. scabiei*. The disease (condition) in man, unlike human scabies, is self- limiting unless there is repeated contact with infected animals. The mites most propably induce hypersensitive reactions that often leads to severe pruritus.

There is some concern that the *Psoroptes* sp. isolated from SACs, referred to as *P. communis*, the cosmopolitan ear mite of many herbivores (Bates, 1999), might be able to infest sheep (and cattle) i.e act as reservoirs for the very serious sheep scab (Foster et al., 2007).

1.6. Diagnosis

The above highlights the importance of a correct diagnosis. The same traditional skin scraping procedures apply for all the three mite species, particularly deep skin scrapings for the burrowing *Sarcoptes* mites, with microscopic identification of the species. In relatively acute infections the mites may be difficult to find. It is necessary to make multiple skin scrapings, employing a blunted scalpel blade often coated with liquid paraffin, on the same individual and on several animals in the affected herd, preferably on all animals. Scrapings should be taken from the edges of active lesions. The thickly crusted parts of chronic lesions often yield high numbers of sarcoptic mites (Figure 6).

Recommended procedures of taking skin scrapings and the following analytical

[2]Bates P., Duff P., Windsor R., Devoy J., Otter A., Sharp M., 2001. Mange mites species affecting camelids in the UK. Vet. Rec. 149, 463-464.

[3]Ruiz-Maldonaldo R., Tamayo L., Dominguez J., 1977. Norwegian scabies due to *Sarcoptes scabiei* var *canis.* Arch Dermatol. 113, 1733.

procedures vary. Often the recommendations are to place the skin scrapings on a glass slide and mix it either with a drop or two of a 10% solution of potassium hydroxide (KOH) followed by applying heat for a few minutes or mix the skin scraping material with liquid paraffin, followed by applying a glass cover slip. This is then examined for the presence of ectoparasites under low power (D´Alterio et al., 2005a).

Another laboratory procedure is to place the scrapings (scabs and debris) preferably in centrifuge tubes allowing the material to be soaked in a 10% solution of KOH and place the mix in a water bath (37°C) for a few hours after which the material is centrifuged at about 3000 r.p.m. Then the supernatant is discarded and the sediment examined in a microscope under low power after adding 1-2 drops of glycerine to the sediment (Bornstein and Zakrisson, 1993).

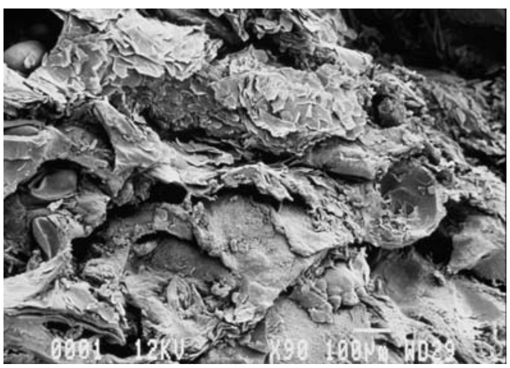

Figure 6. Sarcoptes scabiei, different stages seen in the thickened corneum of a chronically and severly infected animal. This image illustrate why aggressive treatment is sometimes necessary. (SEM, photo: T. Nikkilä/S. Bornstein).

One can often cut the above procedure short by first examining the collected skin scrapings in a small petri-dish which is left in room temperature or up to 35^0C for an hour or two followed by examining the scrapings under low magnification (stereo-microscope). The raised temperature (>+18°C) will stimulate any live ectoparasite present to move, increasing the possibility of detecting parasites that may then be isolated and identified. If no ectoparasite is found the previous described procedures follow**.**

In regards to *Chorioptes* sp. animals may harbour a relatively low level of infestation showing no clinical disease, while other individuals may experience a hypersensitivity reaction with moderate to severe skin lesions including pruritus, similar to the clinical reaction to acute *S. scabiei* infections. A recommended site for performing skin scrapings in search of *Chorioptes* sp. is the dorsal interdigital (between the toes) (Figure 5) and axillae areas (D´Alteiro et al., 2005a).

Low power microscopical examination of material from superficial skin scrapings and swabs rubbed into the outer ear canal may identify *Psoroptes* sp.

For definite identification it is recommended that isolates be sent to experts in the field (i.e. laboratories that specializes in the identification of arthropods).

When diagnosis of skin disease is not conclusive skin biopsies are recommended. Mites are seldom seen in acute cases in histological sections of the skin. However, in cases of chronic sarcoptic mange, *S. scabiei* may often be seen in the epidermis.

1.7. Differential diagnosis

When confronted with pruritic skin conditions one must consider the possibility that these may be caused by mange mite infections/infestations or infestations by lice. There are several other causes of skin lesions which should be mentioned as differential diagnostic possibilities including dermatitis of bacterial, viral and fungal etiology and immune mediated skin disease as pemphigus-like conditions, pemphigus vulgari, drug eruptions etc, hypersensitivity reactions, nutritional /metabolic disease, as idiopathic hyperkeratosis (zinc responsive dermatosis, munge) (Figure 4). Zinc responsive dermatosis, seen in young llamas (one to two years old), is a popular diagnosis, with variable clinical responses following zinc supplementation (Foster et al., 2007). The true role of zinc deficiency is debatable (D`Alterio et al., 2006, Van Saun, 2006).

1.8. Lice

Lice are insects without wings. Their whole life is mostly spent on the same individual host and they are recognized as highly host specific (Wall and Shearer, 2001). However, this is not the case among the different SACs. The lice have a simple life cycle**.** Eggs (nits) are deposited by the female, are glued singly onto fibers close to the skin and give rise to three nymphal stages (Wall and Shearer, 1997, Fowler, 1998). The life cycle, egg to adult takes about 30-35 days according to Wall and Shearer (1997), but according to Fowler (1998) it can be completed within 2-5 weeks. The adult female lays about 30 eggs during her lifetime of 15-40 days.

Bovicola(syn *Damalinia*) (*Lepikentron*) *breviceps* Rudow, 1866 (the biting or the chewing louse), is more common in llamas than in alpacas. It has a blunt broad head that is distinctly different from the elongated mouthparts of sucking lice. *Bovicola (Damalinia) breviceps* is distinguished from other species of the genera by the morphology of their ventral terminalia and the configuration of their sclerites (Lyal, 1985). Infestations on SACs of *B. breviceps* (varying in size from 0.5 x 1.2 to 1.5 x 4 mm) are mostly seen on the dorsal midline, base of the tail, on the side of the neck, and along the sides of the body (Fowler, 1998).

Llamas and alpacas may be infested with three *species of* sucking lice, *Microthoracius* spp. (*M. mazzai*, *M. praelongiceps* and *M. minor*). Alpacas are more often infested with *M. mazzai* Werneck, 1932 characterized by its elongated spindle-shaped head, which is almost as long as its abdomen (Figure 7). Occasionally, the former species has been misnamed *M. prealongiceps (*Cicchino et al., 1998). Preferred sites of attachment are around the flanks, head, neck and withers. Although these lice are large enough to be seen with the naked eye, about two-thirds the size of the biting lice, they are often partly imbedded in the skin feeding on blood and thus it may be difficult to see them.

1.9. Pediculosis

Clinical signs of infestations of *B. breviceps* are often a lack of lustre and a ragged looking coat. Infested animals exhibit pruritus. Heavy infestations result in matting and loss of fibres (Fowler, 1998), but do not seem to have negative effects on the quality of the fibres or pose any health risk to alpacas[4]. Nevertheless severe infestations may result in a reduction of the price of the infested fleece (Vaughan, 2004).

Clinical signs of *Microthoracius* spp are pruritus, restlessness, hair loss and poor growth. Severe infestations can cause anaemia.

Figure 7. Microthoracius mazzai (a sucking louse) commonly found infesting SACs, particularly alpaca (Photo; G Leguia, Univ. of Lima, Peru).

1.10. Diagnosis

Diagnosis is made on the bases of clinical signs and identifications of the lice in coat brushings. Searching for lice need bright light, parting of the fibres down to

[4]Vaughan JL., Carmichael I., 1999. Control of the camelid biting louse, *Bovicola breviceps* in Australia. Alpacas Australia. 27, 24-28.

the skin, meticulous observation for movement of small `specks` and perhaps a magnification glass. The *Microthoracius* spp are seen partly imbedded in the skin taking a blood meal or clinging to a fibre. The characteristic eggs (nits) of the lice may be found attached to the fibres.

1.11. Treatment

A variety of insecticides and acaricides have been used on SACs with varying levels of success. In the past there have been several substances and dosage regimes employed to treat mange mites. However, few of the commonly used acaricidal substances and insecticides have been experimentally evaluated on SACs. There are a limited number of pharmacokinetic studies of the effects of these including the modern macrocyclic lactones on SACs (Jarvinen et al., 2002, Hunter et al., 2004a,b). However, few if any therapeutic products available are licenced for SACs as yet (D`Alterio et al., 2005b).

A number of authors have used ivermectin at 200 µg/kg by subcutaneous injection with variable results against mange mite infestations in SACs (Fowler, 1998, Foster et al., 2007, Twomey et al., 2009). Some have employed higher doses, e.g. 400 µg/kg and with more frequent applications (even weekly) than the recommended standard dosages used for other livestock. Also topical use of products containing ivermectin, eprinomectin, doramectin and moxidectin have proved efficacious in some treatments, but not in others (D`Alterio et al., 2005b, Foster et al., 2007, Lau et al., 2007, Twomey, 2009). Applying injectibles (systemic therapy) in combination with topical treatments is often required to get better results (Curtis et al., 2001). Particularly patients with chronic lesions with thickened crusty hyperkeratotic skin need to be treated aggressively (Figure 6). Perhaps an earlier recommendation to employ hand-dressing of the thick hyperkeratotic areas of the skin with water, soap and keratolytic agents, would shorten the recovery time and reduce the amount of acaricides used (Nayel and Abu-Samra, 1986c, Bornstein, 2002, Lau et al., 2007). Three alpacas were successfully treated locally with rinses of amitraz weekly for 8 weeks following local treatment with keratolytic and antibacterial shampoos (Lau et al., 2007).

Chorioptes sp. infestations have often proved difficult to control and eradicate (Geurden et al., 2003, D`Alterio et al., 2005b). *Sarcoptes scabiei* infections have also been very difficult to treat successfully (Borgesteede et al., 2006). Whether `fomites` play any significant role in regards to re-infection/infestation following treatment is debatable. The ability of *Chorioptes* mites to survive in the environment close to 70 days (depending on conditions including availability of food) may partly explain the limited efficacy of treatments (D`Alterio et al., 2005b). Observations indicate that the *S. scabiei* mites remain infective for only one half to two thirds of their survival time after beeing dislodged from their host (Arlian 1989), and dislodged *Psoroptes* sp. are very sensitive to the microclimate in the environment (Wall and Shearer, 2001).

The fibres of alpacas and llamas do not contain lanolin, which is necessary for the effective spreading of topically applied products, i.e. pour-ons, formulae designed for other livestock than camelids, e.g. cattle and small stock. This may partly explain therapeutic failures on alpacas (see page 3[2]). Another cause may be the observation that some *S. scabiei* strains are resistant to some acaricides e.g. ivermectins (Pasay et al., 2009).

There are numerous insecticides including pyrethrins, chlorinated hydrocarbons, carbamates and organic phosphates, which may eradicate lice (as well as mites and ticks), but the problem is the administration of the products and the toxicity of some of them to humans. Lice infestations are easier to treat than the above mentioned mange mites.

Ivermectin at a dose rate of 200 µg/kg body weight administered subcutaneously is effective against sucking lice (Fowler, 1998), but not against the biting or chewing lice. Cypermethrin at a dose rate of 10 mg/kg has been used with good effect (Palma et al., 2006, Vaughan, 2004). A single treatment is thought to be enough but two treatments 14 days apart is recommended as a backup (Palma et al., 2006). Vaughan (2004) tested a new product, Ectinosad® (Elanco Animal Health) with good results.

The eradication of infestations requires repeated treatments and isolation until the animals are found to be completely free of the parasites. The results of several case reports indicate the need to treat the animals infected/infested with mange mites more frequently and with higher dosages of some of the acaricidal substances used, compared to the formula for ruminants (Foster et al., 2007, Twomey et al., 2009). It is vital to monitor closely the results of the treatments, i.e. the clinical resolution following the therapies employed, before deciding on whether to stop treatment or change the regimen. Successful treatment should be followed by effective biosecurity measures to prevent the risk of re-infection/infestations. In addition, it is recommended to treat all the animals in an infected herd at the same time.

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