

Effect of the prevalence of ectoparasites in the behavioral patterns of wild vicuñas (*vicugna vicugna*)

Yanina Arzamendia¹, Lilia E. Neder², Gisela Marcoppido^{*3}, Felix Ortiz², Martha Arce², Hugo E. Lamas⁴ and Bibiana L. Vilá⁵

¹ National Research Council (CONICET), Vicuñas, Camelidos y Ambiente (VICAM)-FUNDANDES-National University of Jujuy (UNJu), Argentina, ² Instituto de Biología de la Altura, (INBIAL)-UNJu – CONICET, ³ Instituto de Patobiología, CICVyA- INTA Castelar-VICAM, ⁴ Estación Experimental Agropecuaria INTA Abra Pampa, Jujuy, Argentina, and ⁵ VICAM- CONICET- National University of Luján, Argentina.

Abstract

The vicuña (*Vicugna vicugna*) is a wild South American camelid adapted to high Andean arid environments. This species almost became extinct by the middle of the 20th century due to overharvest for their fleece. Nowadays, the increase in their populations is generating conflicts with villagers, who consider vicuñas as transmitters of ectoparasites (mainly mites) to livestock. However, information concerning this issue is scarce, despite the importance of vicuñas and their close phylogenetic relationship with domestic camelids (*Lama glama* and *Vicugna pacos*).

The purpose of this study was to determine the presence and prevalence of ectoparasites in a wild population of the southern vicuña subspecies (*V. vicugna vicugna*) from Cieneguillas, Pozuelos Biosphere Reserve, Jujuy, Argentina, and their effect on the behavioral patterns of the species. We also surveyed ectoparasites in llamas (*Lama glama*) of the study area from 1999 to 2005. Parasites were collected directly from skin examination and scrapings. The ectoparasites detected in vicuñas were *Microthoracius mazzai*, *M. praelongiceps* and *Sarcoptes scabiei*, with a prevalence of 2.44%. These parasites may also infect llamas. Behavior of vicuñas with louse infestation and sarcoptic mange lesions did not differ from those with no clinical signs.

Keywords: ectoparasites, *Lama glama*, *Microthoracius* spp., *Sarcoptes scabiei*, *Vicugna vicugna*.

*Corresponding Author: Gisela Marcoppido, Instituto de Patobiología, CICVyA- INTA, CC 25 (1712) Castelar, Buenos Aires, Argentina. Phone/fax: 54 11 4621 1712. E-mail: gmarcoppido@cnia.inta.gov.ar

Introduction

The vicuña (*Vicugna vicugna*) is a wild South American Camelid (SAC) adapted to high Andean arid environments (Franklin, 1974). It almost became extinct by the middle of the 20th century due to the overharvest for its fine, high quality fleece. After 30 years of effective protection laws, the number of vicuñas of some Argentinean populations has increased, allowing local people to obtain fiber from live vicuñas (Laker et al. 2006; Sahley et al. 2007; Arzamendia and Vilá, 2012). This increase in the number of vicuñas has also generated problems with villagers, who consider vicuñas as reservoirs of ectoparasites (mainly those that cause mange) for their livestock (Arzamendia, 2008). However, information concerning the role of vicuñas in the transmission of parasites is scarce (Leguía, 1991a), despite the importance of vicuñas as a financial resource and their close phylogenetic relationship with domesticated SACs (i.e. the llama (*Lama glama*) and the alpaca (*Vicugna pacos*)).

Ectoparasites are organisms that live on the outer surface of other organisms and affect the productivity of the animals, causing pruritus, hair loss and poor growth. In SACs, the ectoparasites affect both the harvest and quality of the fleece due to the mechanical damage to the epidermis and fiber and disturbing the development of the animal, with the compromise of the local economies

(Cicchino et al., 1998; FAO 2005, Bornstein and de Verdier, 2010).

In domestic SACs, mites and sucking lice infestations are the most common parasitic problems identified by owners, even in countries outside South America (Leguía, 1991a; Cicchino et al., 1998; Solis Hospinal, 2000; Twomey et al., 2009; Lusat et al., 2009, Bornstein et al., 2010). Previous studies have reported the presence of *Microthoracius praelongiceps*, *M. mazzai*, *M. minor*, *Amblyomma parvitarsum* and *Sarcoptes scabiei* in the northern vicuña subspecies (*V.v. mensalis*) of Peru (Dale and Venero, 1977) and Bolivia (Beltrán Saavedra, 2008). There is only one report available on vicuñas of Argentina (*V.v. vicugna*) affected by *M. praelongiceps* and *M. minor* (Castro and Cicchino, 1998).

Microthoracius spp. (Phthiraptera: Anoplura) are obligate blood sucking lice which causes infestations characterized by licking, scratching and rubbing. Heavy infestations may produce anemia, especially in young and stressed animals (Kaufmann, 1996; Cheney and Allen, 1989). These sucking lice are frequently found in camelid herds in South America (Leguía, 1991a; Solis Hospinal, 2000; Arce and Ortiz, 2004; Bornstein and de Verdier, 2010).

Sarcoptes scabiei (Acari, Astigmata: Sarcoptidae) is a burrowing mite that causes a dermatitis characterized by pruritus, alopecia and

epidermal hyperplasia with desquamation (Bowman, 1995). Sarcoptic mange, which is caused by *S. scabiei*, is a highly contagious disease, also considered the cause of mange epizootics, which has significantly affected wild and domestic mammals worldwide (Bornstein et al. 2001; Pence and Ueckerman, 2002). *S. scabiei* var. *aucheniae* can also be cross-transmitted among alpacas, domestic sheep, horses, goats, dromedaries (Smith et al., 2009; Bornstein, 2010; Bornstein and de Verdier, 2010). The persistence of the infection in the SACs leads to a chronic stage which includes crusting, alopecia, lichenification and thickening of the skin (hyperkeratosis). Fiber-free areas seem to be more often affected. Lesions may be seen on the limbs, medial thighs, ventral abdomen, chest, axilla, perineum, prepuce and head, including the lips and ears. Intense itching, scratching and rubbing produce a self-trauma with visible deterioration of the physical condition, progressive emaciation and reduce weight gain. Severe infestations may result in death (Bornstein and de Verdier, 2010). Infestations with *Chorioptes* sp. and *Psoroptes* sp. can also be found in SACs, and even mixed infections with three mite species can occur (Bornstein, 2010).

Historical epidemics of *S. scabiei* var. *aucheniae* have been reported in SACs in South America, with a prevalence range from 25% to 95% (Leguía, 1991; Fowler, 1998; Ramos Acuña et al., 2000; Bornstein

and de Verdier, 2010). The mite burrows into the epidermis causing intense irritation. Some reports have established that while lightly infested individuals may suffer only short-term negative effects, densities of mites over 5000 specimens/cm² can lead to secondary infections, starvation, dehydration and even death (Twomey et al., 2009; Bornstein and de Verdier, 2010). Sarcoptic mange epidemics can cause significant (up to 50–90%) population declines in wildlife (Bornstein et al., 2001), and even lead to the extinction of local populations of wild species (Pence and Ueckerman, 2002), already threatened by other factors such as habitat loss and overexploitation.

Because no data of prevalence of ectoparasites on wild vicuñas are available, the purpose of this study was to determine their presence and prevalence in a wild population of the southern vicuña subspecies (*V. vicugna vicugna*) from Cieneguillas, Jujuy, Argentina, and their effect on the behavioral patterns of this species.

Materials and Methods

The study area was located in Cieneguillas (66° 15'W, 21° 50'S), in the Pozuelos Biosphere Reserve, in the northwest of Argentina, 3,700 m.a.s.l. The environment is dominated by a dry steppe with stony and sandy soils. The climate is arid with high diurnal temperature fluctuations throughout the year (up to 30°C) as well as frequent frosts. Rains are scarce (350 mm/year)

and seasonal (December to March), and strong, dry winds are frequent. The study took place in five areas (sites 1 to 5; 2,540 hectares). These areas are involved in vicuñas conservation attempts, and have 12 to 40 vicuñas/km² (Arzamendia and Vila, 2006) and livestock production, with densities of 11 to 70 llamas/km² and 23 to 256 sheep/km². Disease control in livestock is limited to the treatment for ectoparasites with subcutaneous Ivermectin injections (Ivomec 1%, Merial) at a dose of 1 ml/25 kg bodyweight. The Ivermectin treatment was used as a preventive measure in sites 1 to 3, with two doses given at a 14-day interval, repeated twice a year in March and November; while in sites 4 and 5 only two subcutaneous Ivermectin injections were given 14 days apart, once a year and only on infested llamas. No anti-parasite treatment was applied on wild vicuñas.

In total, 450 vicuñas were captured (364 individuals plus 86 recaptured) between November 2003 and November 2005 as part of a study of the sustainable use of the species. Before their release, the 364 vicuñas were identified with a numbered necklace of flexible plastic and ear tags, allowing individual recognition from up to a 300m distance. Eighty-six out of the 364 vicuñas were re-captured two years later (2005) and examined for the presence of ectoparasites (Table 1). Capture permissions were obtained from the Direction of Natural Resources and Environment (Dirección de

Recursos Naturales y Medio Ambiente) of Jujuy, Argentina. In addition, pastoralists collected lice from two live llamas and crusts from another two dead llamas. Ectoparasites were collected from live marked vicuñas and from two carcasses found in the open field. The presence of parasites, eggs/nits and mange-like lesions were recorded, and deep skin scrapings were taken from mange-like lesions using a curette. Louse specimens were collected using tweezers. Both sample types were fixed with 70% ethyl alcohol for subsequent examination at the laboratory. The skin scrapings were macerated in a 5% potassium-hydroxide solution and washed with distilled water until dissolution. Lice were examined under a microscope (X50) and identified based on Leguía and Casas (1999) and Castro and Cicchino (1998) and mites were identified using Del Ponte (1958) and Doreste (1988) keys. Voucher specimens were deposited in the entomological collection of the Instituto Nacional de Biología de la Altura (INBIAL), National University of Jujuy, Argentina.

Table 1. Captured wild vicuñas and shearing management in Cieneguillas, Province of Jujuy, Argentina. Numbers of animals captured (N Capt.) at each site and time of capture, numbers of individuals per sex and/or age, with ectoparasites (*S. scabiei* and *Microthoracius* spp).

SITE	Time Capture	N capt	♂ capt	♀ capt	Calf capt	Individuals with <i>S. scabiei</i>			Individuals with Phthiraptera			Species of Phthiraptera
						♂	♀	Calf	♂	♀	Calf	
1	May-03	43	30	9	4	0	0	0	0	0	0	
1	Nov-03	84	43	31	10	1	0	0	0	0	1	<i>M. mazzai</i>
1	Nov-05	108	42	41	25	0	0	0	0	0	0	
2	Nov-03	2	0	2	0	0	0	0	0	0	0	
3	Nov-04	82	34	28	20	0	0	0	0	0	0	
4	Nov-04	86	57	16	13	1	1	0	1	2	0	<i>M. praelongiceps</i>
5	Nov-05	45	18	18	9	0	1	0	1	2	0	<i>M. mazzai</i>
total		450	224	145	81	2	2	0	2	4	1	

We recorded the behavior of marked vicuñas in 2003 ($n = 98$) for up to 2 years after capture (Arzamendia and Vilá 2012), in order to identify alterations in their daily activity patterns associated with ectoparasite infestations. We used focal animal sampling (Martin and Bateson 1986) with 26 15-min samplings. We recorded standardized behaviors (i.e., grazing, standing, alert, walking, running, lying, grooming, suckling), using prismatic binoculars (12x50, 20x80) as described in Arzamendia and Vilá (2012). We also recorded events which included vocalization, excretion, rolling, scratching, and aggression. Each behavioral input datum referred to the number of minutes in which a particular behavior occurred in a 15-min observation period. We tested behavioral differences between vicuñas with and without mange lesions by Friedman's test (Siegel, 1991). We also used ad libitum sampling (Martin and Bateson, 1986) to record relevant events (e.g. scratching), when we observed the marked vicuñas with mange beyond the period of focal sampling.

Results

After careful examination of the skin and fur of each of the sampled animals, lice identified as *Microthoracius mazzai* (Werneck) were collected from wild vicuñas and llamas, whereas lice identified as *M. praelongiceps* (Neumann) were recovered from wild vicuñas. Mites identified as *S. scabiei* (De Geer) were

found in skin scrapings from all the animals sampled with mange-like lesions (Fig. 1). *M. mazzai*, *M. praelongiceps*, and *S. scabiei* were not observed coexisting in the same hosts. Prevalence of ectoparasites in the wild vicuñas during the study period was 2.44% (11/450), including recaptured animals (Table 1). Louse infestation (*M. mazzai* and *M. praelongiceps*) was 1.56% (7/450), with few specimens in adult vicuñas (<5 lice per animal) and more specimens in one calf (≥ 25 lice) (Table 1). Lice were located on the neck and on the scapular, dorsal and lumbar regions of the body. The presence of *S. scabiei* in vicuñas was 0.88% (4/450) (Table 1) and was associated with sarcoptic mange (alopecia, crusts and matted hair) in the axilla, groin and medial parts of the limbs in two adult males and two adult female's vicuñas. Skin scrapings and crusts collected from two unmarked wild vicuñas found dead in the open field were also positive to *S. scabiei*. Clinical signs included alopecia and matted hair mainly distributed over the legs and chest, and crust formation on the groin. The cause of death could not be confirmed in either of the two cases. After the capture of November 2003, 97% of 98 marked vicuñas could be identified in the study sites representing 20 social groups: family groups, bachelors and solitary individuals. The remaining 3% was comprised of 2 death animals, killed by predation and 1 vicuña not found in the area (Arzamendia, 2008).

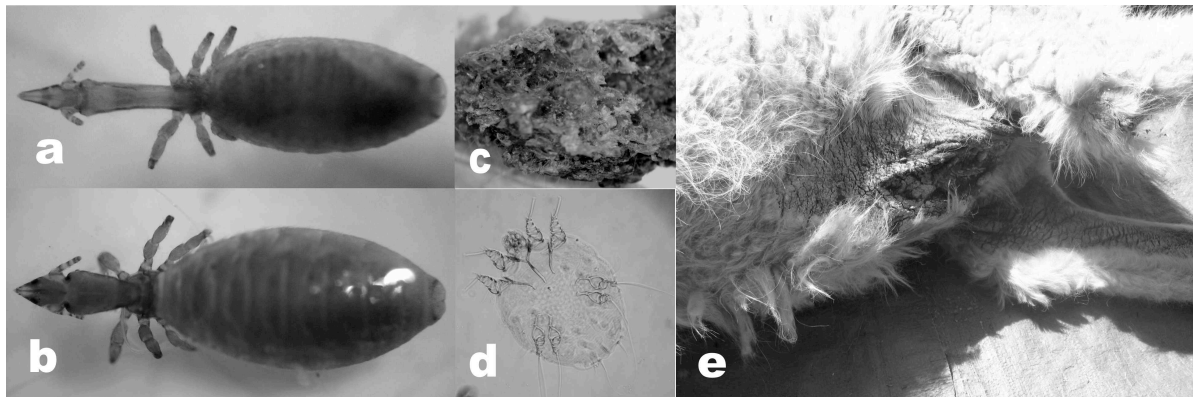
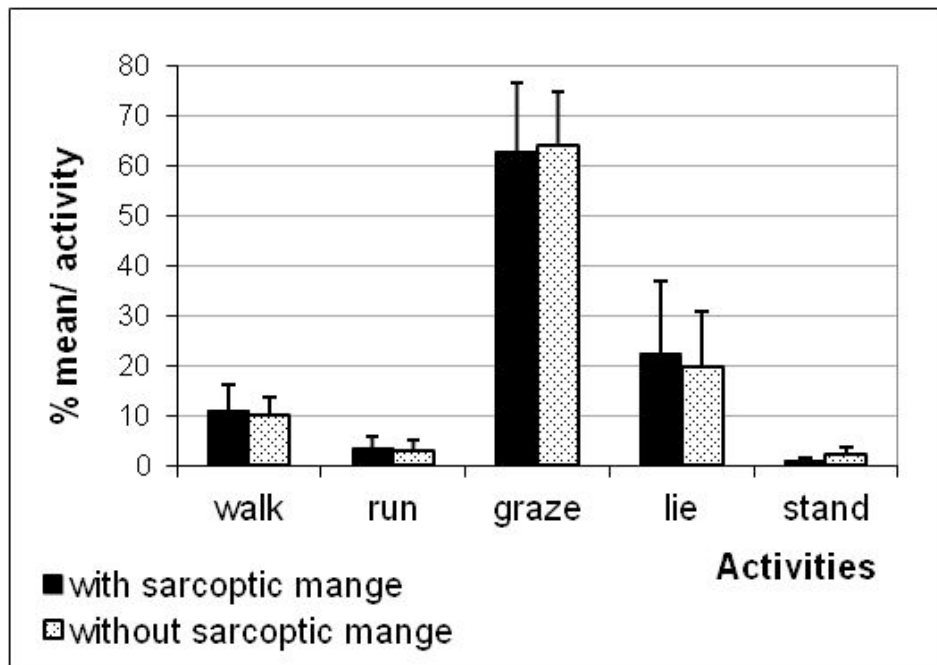


Figure 1. Ectoparasites found in vicuñas: a) *Microthoracius mazzai*, b) *Microthoracius praelongiceps*; c) Section of skin in sarcoptic crust; d) *Sarcoptes scabiei*; e) Location and clinical signs of sarcoptic mange.

Only three male vicuñas from one of the bachelor groups (n=32) were observed with lesions associated to chronic sarcoptic mange, showing crusting and intense alopecia mainly on the lower limbs, and abdomen. Two of these males were captured and sampled,

not observe significant differences in the behavior of individuals with and without clinical signs of mange. The principal activity was foraging, followed by resting and moving (Fig. 2).



resulting positive to *S. scabiei*. We did

Figure 2. Mean percentage of activity budget/behavior in animals with and without sarcoptic mange lesions, measured with the T^2 value (Friedman's test).

Other activities presented low frequency in both groups (defecating, rolling, grooming) ($T^2=1$, $P=0.35$). Vicuñas with mange lesions showed similar inter-individual distance with the vicuñas without mange lesions, except for one observed male who left the group ten months after the lesions spread from the axillae to the foot. Neither lameness nor pruritus was observed in any of the affected animals.

Discussion

Using direct evidence, in the present study we demonstrated the presence of *M. mazzai*, *M. praelongiceps* and *S. scabiei* in wild vicuñas of Argentina. Several studies published on ectoparasites in domestic SACs from South America and in various countries outside of South America, described mange mites as a common infestations on llamas and alpacas (Cicchino et al., 1998; Twomey et al., 2009; Lusat, et al., 2009; Bornstein and de Verdier, 2010). Some studies have estimated mortalities of over two thirds of the domestic SAC populations in America (Alvarado et al., 1966) and a prevalence of infection between 20-40% in alpacas from Peru (Leguía, 1991a). We found no previous information available for *M. mazzai* and *S. scabiei* in wild vicuñas. Although several authors have reported concurrent infestations with multiple ectoparasitic species in the same host

(Leguía and Casas, 1999; Bornstein, 2010), no mixed infections were observed in this study.

Mange has been described as a behavioral stressor in vicuñas since it affects the animals behavior because of the permanent pruritus (Hofmann et al., 1983). However, in this study we observed no differences between the behavior of vicuñas with mange lesions and those without clinical signs of the disease.

Mites are highly contagious by direct physical contact between hosts and it is usually a problem that affects the whole herd (Pedersen et al., 2007) aggravated by deficient management and stressful conditions of overgrazing, and also due to deficient hygiene in corrals (Cicchino et al., 1998). It is important to highlight that some authors have recognized that *S. scabiei* var. *aucheniae* should be regarded as zoonotic, named pseudoscabies (Kaufmann, 1996; Foster et al., 2007). Livestock production kept at high densities can be responsible for the risk of cross-species transmission to wildlife (Pedersen et al., 2007). In the vicuña, infection has been recorded by transmission of ectoparasites from alpaca herds (Hofmann et al., 1983). In Cieneguillas, the vicuña lives in social groups, sharing the pasture with llamas and sheep. This living limits the carrying capacity of the grazing areas,

acting as a risk factor for cross-species transmission (Arneberg et al., 1998). Cross-transmission of some strains of *S. scabiei* between their wild and domestic hosts is possible (Pence and Ueckerman, 2002; Bornstein and de Verdier, 2010). Close contact is a major route for the transmission of these harmful parasites (Pedersen et al., 2007). In vicuñas, this can occur during the aggressive encounters between males, during mating, in the mother-calf dyad interactions (Vilá, 1992; Arzamendia, 2008), and during the use of communal dust bathing areas and dung piles, which are shared by individuals of the group, and also by neighboring groups and domestic camelids (llamas and alpacas). Nevertheless, in Peru, no invertebrates have been found in the dust bathing areas (Hofmann et al., 1983). According to this social behavior and close interaction within camelids, we would expect a higher infestation of ectoparasites. Nevertheless, the low prevalence of parasites observed in the wild population agrees with the low prevalence reported in wild vicuñas from Peru (Hofmann et al., 1983). The ordinary therapeutic and preventive treatment with Ivermectin practiced for several years on llamas to prevent ectoparasites infestations could be the key to these observations (Ramos Acuña et al., 2000; Pedersen et al., 2007), since sarcoptic mange (*S. scabiei*), and lice (*M. praelongices*) has been reduced considerably in domestic SACs receiving deworming schedules for several decades (Ramos Acuña et

al., 2000; Marley and Conder, 2002; Bornstein and de Verdier, 2010). The conservation and management of wild vicuñas in extensive livestock production areas is an alternative income strategy for the local communities, as well as a way to protect this emblematic species. Therefore, the minimization of contacts between domestic animals and vicuñas is almost impossible. The improvement of sanitary management of domestic camelids appears to be the best strategy to reduce the risk of transmission of diseases to wild vicuñas (Pedersen et al., 2007). The prevalence of ectoparasites in livestock has not been studied in the area. There are a few reports concerning the presence of ectoparasites which recorded *S. scabiei*, *M. mazzai*, *M. minor*, *M. praelongiceps* and *Ablyomma parvitarsum* in llamas, and *Linognathus ovillus*, *L. pedalis*, *Bovicola ovis*, *melophagus ovinus*, and *Otobius megnini* in sheep herds in the studied area (Arce and Ortiz 2004). The present study represents the first report of *S. scabiei* and *M. mazzai* in wild vicuñas from Argentina and demonstrates the need of additional work in order to better understand the ectoparasite epidemiology in wild vicuñas. We highlight the necessity of further studies addressing the prevalence of ectoparasites infections in wild and domestic populations of SACs and livestock in the north of Argentina and develop more systematic research on doses and effects of ectoparasites drug in camelids. The knowledge about parasitic agents affecting SACs should

be taken into account in sustainable management programs of domestic and wild camelids and in the conservation of wild vicuña populations.

Acknowledgments

We thank the Argentinean National Research Council (CONICET) and MACS project (INCO II-ICA4-2000-10229) for financial support. We thank A. Wawrzyk, J. Baldo, M. Borgnia, H. Yacobaccio, D. Baldo, S. Romero and M. Morales, and MACS team Chile. Dr. A. Carbajo provided invaluable advice on statistical analyses. We thank Cecilia Baillo for English revision. We are also grateful to Los Pioneros Association, the Cieneguillas, Tafna and Cusi Cusi communities.

References

- Arce, M., Ortiz, F., 2004. Ectoparasitos (Insecta y Arachnida) sobre animales domésticos de la quebrada de Humahuaca y puna (Jujuy, Argentina). *Idesia* 22, 55-56
- Alvarado J., Astrom G., Heath G.B.S, 1996. An investigation into remedies of Sarna (sarcoptic mange) of alpacas in Peru. *Expl. Agric.*, 2, 245-25
- Arneberg P., Skorping A., Grenfelland B., Read, A. F., 1998. Host densities as determinant of abundance in parasite communities. In *Proc Royal Soc London, Series B*, 267,1283-1289
- Arzamendia Y., 2008. Estudios etoecológicos de vicuñas (Vicugna vicugna) en relación a su manejo sostenido en silvestría, en la Reserva de la Biosfera Laguna de Pozuelos (Jujuy, Argentina). Doctoral Thesis, Universidad Nacional de Córdoba, Córdoba, Argentina
- Arzamendia Y., Vilá B. L., 2006. Estudios etoecológicos de vicuñas en el marco de un plan de manejo sustentable: Cieneguillas, Jujuy. In (Ed. B.L. Vilá) *Investigación, conservación y manejo de vicuñas. Proyecto MACS*, Buenos Aires, Argentina, 69-83
- Arzamendia Y., Vilá B., 2012. The Effects of Capture, Shearing and Release on the Ecology and Behavior of Wild Vicuña. *J. Wildlife Manag.* 76 (1):57–64
- Beltrán Saavedra L.F., 2008. Proyecto sanidad en vicuñas y ganado del Anmin Apolobamba. Informe de avance y resultados de 2006 - 2007. WCS- SNAP, La Paz, Bolivia
- Bornstein S., Mörner T., Samuel W.M., 2001. *Sarcoptes scabiei* and sarcoptic mange. In (Eds. W.M. Samuel, M.J. Pybus and A.A. Kocan), *Parasitic disease of wild mammals* Iowa State University Press, Ames, USA, 107–119

- Bornstein S., 2010. Important ectoparasites of Alpaca (*Vicugna pacos*). Acta Vet Scand, 52, S17. DOI:10.1186/1751-0147-52-S1-S17
- Bornstein S., de Verdier K. 2010. Some important Ectoparasites of Alpaca (*Vicugna pacos*) and Llama (*Lama glama*). J Cam Sci. 3: 49-61
- Bowman D.D., 1995. Georgis' Parasitology for Veterinarians. 6th ed. W.B. Saunders Company. Philadelphia, London, Toronto, Montreal, Sydney, Tokyo. ISBN 0-7216-5589-0
- Castro D., Cicchino A.C., 1998. Anoplura. In: Biodiversidad de artrópodos argentinos J. Morrone and S. Coscaron (Eds), Editorial Sur, Buenos Aires (Argentina), 125-139
- Cicchino A.C., Muñoz Cobeñas M., Bulman G.M., Diaz J.C., Laos A., 1998. Identification of *Microthoracius mazzai*: Phthiraptera, Anoplura, as and Economically Important Parasite of Alpacas. J. Med. Ent., 35, 922-930
- Cheney, J.M., Allen, G.T. 1989. Parasitism in Llamas. In: Vet. Clin. North Am. Food Anim.Pract., LaRue W. Johnson (Ed) 5; 1, 217-225
- Dale W.E., Venero J.L., 1977. Ectoparasitic insects and mites on vicuña in Pampa Galeras, Ayacucho. Revista Peruana de Entomología, 20, 93-99
- Del Ponte E., 1958. Manual de entomología médica y veterinaria argentinas. Ediciones Librería del Colegio, Buenos Aires (Argentina), 349 pp
- Doreste E. S., 1988. Acarología. IICA, San José, Costa Rica. 410 pp
- FAO, 2005. Situación actual de los Camélidos Sudamericanos en Argentina. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Oficina Regional para América latina y el Caribe. FAO/RLC
- Foster A., Jackson A., D'Alterio G.L., 2007. Skin diseases of South American camelids. In Pract., 29. 216-223
- Fowler, M. 1998. Medicine and Surgery of South American Camelids: Llama, Alpaca, Vicuna, Guanaco. 2 nd Ed. Iowa State Press. 549 pp
- Franklin W.L., 1974. The social behaviour of the vicuña. In: The behaviour of ungulates and its relation to management V. Geist and F. Walther (Eds), IUCN, Morges, 477-487
- Hofmann R. K., Otte K., Ponce Del Prado C., Ríos M.A., 1983. El manejo de la vicuña silvestre. Vol. 1. Eschorn: GTZ, 376 pp

- Kaufmann J., 1996. Parasitic Infections of Domestic Animals: a diagnostic manual. Birkäuser Verlag, Basel, Boston, Berlin, ISBN 3-7643-5115-2
- Laker J., Baldo J. L., Arzamendia Y., Yacobaccio H., 2006. La vicuña en los Andes. In (Ed. B. Vilá) Investigación, conservación y manejo de vicuñas, Proyecto Macs, Buenos Aires, Argentina, 37-50
- Leguía G., 1991a. Enfermedades Parasitarias. In: Avances y perspectivas del conocimiento de los Camélidos Sudamericanos. Fernandez-Baca, Saul (Ed). FAO. Santiago de Chile (Chile)
- Leguía G., (1991) The epidemiology and economic impact of llama parasites. Parasitology Today, 7, 54-56. DOI:10.1016/0169-4758(91)90190-Y
- Leguía G. , Casas E., 1999. Enfermedades parasitarias y atlas parasitológico de camélidos sudamericanos. Ediciones Del Mar, Lima (Perú). 149 pp
- Lusat. J., Morgan, E.R., Wall R., 2009. Mange in alpacas, llamas and goats in the UK: Incidence and risk. Vet. Parasitol. 163 (2009), 179-184
- Marley, S.E., Conder, G.A., 2002. The use of macrocyclic lactones to control parasites of domesticated wild ruminants. In: Macrocyclic lactones to antiparasitic therapy. Vercruysse, J. and Rew, R.S. (Eds). CABI Publishing, USA, 425 pp
- Martin P., Bateson P., 1986. Measuring behaviour: An introductory guide. Cambridge University press, Cambridge (UK), 200 pp
- Pedersen A.B., Jones K.E., Nunn C.L., Altizer S., 2007. Infectious Diseases and Extinction Risk in Wild Mammals. Conservation Biology, 21, 1269-1279. DOI: 10.1111/j.1523-1739.2007.00776.x
- Pence D.B., Ueckermann E., 2002. Sarcoptic mange in wildlife. Revue Scientifique et technique d'Office International des Epizooties, 21, 385-398
- Ramos Acuña H., Catrejon Valdez M., Valencia Mamani N., Sas Zeballos P., 2000 Control de Sarna Sarcóptica (Sarcoptes scabiei var. aucheniae) en alpacas (Lama pacos) en Perú, con Ivermectina 1% P/P inyectable de larga acción. Producción animal. www.produccion-animal.com.ar
- Sahley C.T., Torres Vargas J., Sanchez Valdivia J., 2007. Biological Sustainability of Live Shearing of Vicuña in Peru. Conservation Biology 21, 1, 98–105. DOI: 10.1111/j.1523-1739.2006.00558.x

- Siegel S., 1991. Estadística no paramétrica aplicada a ciencias de la conducta. Triller, Mexico
- Smith K.F., Acevedo-Whitehouse K., Pedersen A. B., 2009. The role of infectious diseases in biological conservation. *Animal Conservation* 12, 1-12. DOI: 10.1111/j.1469-1795.2008.00228.x
- Solis Hospinal R., 2000. Enfermedades Infecciosas y Parasitarias en alpacas. In: Producción de Camélidos Sudamericanos. R. Solis Hospinal (Ed). Huancayo (Perú). 229-284
- Twomey D.F., Birch E.S., Schock A., 2009. Outbreak of sarcoptic mange in alpacas (*Vicugna pacos*) and control with repeated subcutaneous ivermectin injections. *Vet. Parasitol.*, 159, 186-191. DOI: 10.1016/j.vetpar.2008.10.023
- Vilá B. L., 1992. Vicuñas (*Vicugna vicugna*) agonistic behaviour during the reproductive season. In: Ongulés/Ungulates. F. Spitz, G. Janeau, G. Gonzalez and S. Aulagnier (Eds) 91, 475-482