Vicuña Ecology and Management

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The vicuña (Vicugna vicugna) is the smallest living member of the camel family (Camelidae). It dwells 3,000 to 4,600 meters above sea level on the high Andean plateau of central and southern Peru, western Bolivia, northern Chile and northwestern Argentina. There it inhabits the puna, a high altitude steppe-like grassland and desert that is treeless and located above the zone of cultivated crops.

The vicuña is well adapted to living in this harsh environment. It is clothed in a fleece of the finest known wool, one that has been valued and harvested by man since pre-Columbian times. This fleece protects the vicuña from the extreme cold and winds of the puna, and also provides a cushion for its body when resting on the ground. In comparison to old world camels, the vicuña has more deeply cloven feet, which allow it to walk and run more adeptly on the rocky slopes, cliffs and rockslides that are common on the puna[32]. Another important adaptation is the vicuña's rodent-like teeth, which grow continuously and allow the vicuña to "graze upon small forbs and perennial grass close to the ground [20;48]." The vicuña is the "only ungulate that has these open-rooted, continuously growing incisors [39;20;48]."

The vicuña shows interesting similarities to the pronghorn antelope (Antilocapra americana) of North America[32]. Although unrelated, both of these inhabitants of windswept grasslands are of similar size and extremely swift of foot, running away at incredible speeds to escape danger. Both are also strongly inquisitive, walking "toward any moving object that is partly hidden, as if to identify it by closer inspection[32]."

The vicuña is one of four living representatives of the camel family that are found in South America, the other three being the guanaco (Lama guanicoe), llama (Lama glama) and alpaca (Vicugna pacos). Figure 1, Figure 2. The vicuña and guanaco are wild species, while the llama and alpaca are domesticated. In this review, I discuss the ecology and management of the vicuña.

Figure 1. Alpacas grazing in a Peruvian vega. The alpaca is a domestic camelid derived from the vicuña. Genetic studies estimate that it was first domesticated in the Peruvian Andes 6000 to 7000 years ago. Photograph by Stuart Pattullo.

Figure 2. "Cuteness Overload" A baby alpaca attracts attention on a street in Perú. Photograph and title by Stuart Pattullo.

Geographic Distribution and Races

The vicuña currently inhabits the high Andes between latitudes 9o 30' south and 29o 00' south. In the past, however, its range extended much further to the north. For example, in the sixteenth century, Cieza de Leon ([1550] 1984) mentioned vicuñas living near Huamachuco, Peru, and in the regions of Loja and Riobamba, Ecuador.

Two geographic subspecies of the vicuña are recognized: a southern race Vicugna vicugna vicugna, and a northern race Vicugna vicugna mensalis[57;44]. The approximate dividing line between these two races is 18o south latitude, however, the exact boundary has not been mapped and the recent rapid population recovery makes it difficult to elucidate past distributions of the two subspecies. The southern race is both larger and lighter in color than the the northern race.

Relationship to Domestic Camelids

For many years, the origins of South America's domestic camelids, the llama and alpaca, were unclear due to "hybridization, near extirpation during the Spanish conquest and difficulties in archaeological interpretation[31]." Biologists long assumed that both the alpaca and llama were descended from the guanaco, and that the vicuña had never been domesticated. However, recent genetic research suggests that while the llama is indeed descended from the guanaco, the alpaca is descended from the vicuña[31]. The time and place of the domestication of the alpaca is now estimated to be "6000–7000 years before present in the Peruvian Andes[31]."

The genetic studies also show that the northern race of the vicuña, V. v. mensalis is the one most closely related to the alpaca, while the southernmost vicuña V. v. vicugna is most closely related to a basal taxon (i.e. a primitive South American camelid)[31].

Social organization

The vicuña is a social animal and typically occurs in herds. Solitary individuals are rare. Herds are of two kinds: (1) family groups, and (2) male troops.

A family group is created by a dominant male that establishes and maintains a permanent year-round territory[36], the size of which varies depending upon the quality of grazing forage and other resources[29]. A family group consists of this dominant male, multiple adult females, juvenile females (one or more years of age) and offspring of both sexes younger than one year of age [19;64;9].

A male troop is composed of juvenile males (one to four years old) that have been expelled from their family groups, and

ageing males that have lost their territories. Unlike family groups, male troops do not hold territories and do not seem to have leaders[32]. They constitute a temporal non-reproductive category [20]. Male troops are also called "bachelor groups."

Solitary vicuñas are either single adult males without territories, or single adult males with territories but without females. Some are former leader males that have been displaced from their territories by new males. Solitary vicuñas constitute another non-reproductive unit[25].

Because male and female vicuñas look so similar, it is sometimes difficult to tell whether a band of vicuñas is a family group or a male troop. However, during autumn, winter and early spring, family bands can be recognized because they include offspring younger than one year of age[32].

Communal Dung Piles

Vicuñas and other South American camelids defecate and urinate on communal dung piles. All individuals of a band, whether it be a family group or a male troop, use the same dung piles, and "displaced bands freely use dung piles situated on the territories of other bands [32]." Even more remarkable is the fact that "alpacas and lamas use the same dung piles that are used by vicuñas [32]."

A typical communal dung pile is said to be "one foot thick at the center and five yards in diameter[32]." Where vicuñas are common and the ground is flat, dung piles may be regularly spaced, about fifty yards apart[32].

An important ecological question that needs to be answered is: "what effect do these dung piles have on the growth, distribution and abundance of the various plants and animals of the puna?" According to Koford (1957), "most of the plants that grow on or close to these piles are conspicuously different from the plants of the surrounding pasture," and "late in the wet season, brilliant green circular spots mark the location of dung heaps, and on many barren hills these spots are the only greenery that can be seen from a distance."

Predators

In settled areas, domestic dogs from local villages kill vicuñas more frequently than any other non-human predator[32]. Nevertheless, there are also native carnivores that prey upon vicuña and these include the puma (Puma concolor) and Andean fox (Pseudalopex culpaeus)[10]. The latter species has been called the "ecological equivalent" of the coyote (Canis latrans) of North America [32].

Like the pronghorn antelope of North America, newborn vicuñas can run away from predators soon after birth. For example, an infant vicuña observed by [32], held its neck and head up 20 minutes after birth, and walked a hundred meters up across a rocky moderate slope following its mother one hour after birth. Within 3 hours of birth, it was seen running 200 meters across a rocky slope at a speed of 24 kilometers per hour with its mother.

The newborn vicuña is thus most vulnerable to predators during the first hour after birth. Koford (1957) observed a vicuña giving birth and found that within a minute after the young dropped to the ground, 5 adult Andean Condors (Vultur gryphus) landed 9 meters uphill from the newborn. Within 20 minutes, more condors arrived swelling the total to 14 condors. Defensive behavior of the mother vicuña, and other pregnant females in the family group, prevented the condors from approaching closer than about 2 meters of the helpless newborn. Within a half hour the condors departed. This bird is otherwise unable to prey upon living vicuñas, despite the fact that it is often seen eating the carrion of dead vicuñas.

Habitat Selection

Although the vicuña is restricted to the puna, it does not use all parts of this arid ecosystem. In the Argentinian Andes, vicuñas were absent from the most common habitat of the puna, the peladar, which was a wide open area of "rocky bare soil where isolated shrubs of Acantholippia hastulata" sometimes occurred[48]. In contrast, vicuñas preferred grazing in the least common habitat of the puna: the vega, a swampy area usually less than one hectare in area that was "associated with ground water, lagoons or streams," and that created

"locally moist edaphic conditions, where hardy grass and green herb, represented by Oxycholoe sp. and rizomateus species, covered almost 100% of the soil [48]." Preference for vegas was also reported by Glade (1987), Lucherini and Birochio (1997) and Lucherini et al. (2000). See color photo: Figure 3.

Figure 3. Vicuña grazing in a vega, a well-watered and highly-productive habitat in the otherwise arid puna. Note the contrast between the green vegetation of the vega and dry vegetation of the arid slope. Vegas produce a profusion of grasses and herbs that are fed upon by vicuñas and other camelids. Photograph by Dirk Lingstädt (Germany).

Koford (1957) reported that although vicuña territories included wetlands, they were usually located near ascending slopes. He noted that vicuña escape from some predators by running to steep slopes, and that vicuña use dry sites on "moderate slopes, well downhill from ridgetops" as bedding places to spend the night. Another value of slopes is that the bases of slopes are often good places for grazing because the soil there is deeper and moister than higher up on the slope[32].

Habitat use varies according to time of day. In extensive zones of the Andes, vicuñas spend the night, early morning and late afternoon on the slopes. Later in the morning, they descend to the vegas where they graze extensively [25; 48].

Vicuñas drink water every day and are usually found within two kilometers of water[32]. This water can be a lake, stream or spring, but often even a pool alongside a road or a puddle on a mat of vegetation will suffice[32].

In a part of the Argentinian Andes that lacked permanent human settlements, Lucherini et al. (2000) found that during a year when pumas invaded their study site, male troops of vicuñas decreased time spent in the vegas and other vegetation within 100 meters of a river, and increased time spent in more sparsely vegetated areas over one-half kilometer from the river. These researchers believed that the reason for the vicuña habitat shift was fear of the pumas, which hunted more frequently along the river and killed more vicuñas there.

Activity Patterns

During autumn in Argentina, vicuñas spend more time foraging for food and less time resting than during summer [60]. In both seasons, vicuñas drink water throughout the day, with peak drinking at noon[60]. However, vicuñas drink water more frequently in the afternoon during summer than during autumn[60]. An explanation for these differences is that ambient temperatures and humidity are also higher in summer than in autumn [60].

In Chile, Glade (1987) observed that the birth season occurred between the second week of February and last week of March, with 65-68 live young per 100 births. Fourteen percent of calves died within 3 months, and calf mortality reached 17.6% by one year of age. The surviving calves were rejected from the family groups when they were between 6 and 12 months old and 54.5% of total expulsions occurred in February. Glade also described the sex ratio in adult vicuñas as 33 males per100 females, and the mean family group size as 5.6 individuals (1 leader male, 3 females and 1.6 calves).

Interactions between camelids

Vicuñas can be seen foraging near domestic herds of llamas, alpacas and even sheep during the day, mainly in meadows or bofedales. Daily herding practices are very low intensity, and shepherds typically move their domestic herds from corrals to the meadows for grazing during midday.

Such close distance grazing is common on the altiplano, with little disturbance caused to the vicuñas. However, the close proximity of vicuñas with domestic herds facilitates inter-specific disease transmission. In addition, vicuñas are sometimes herded back to corrals with llamas and alpacas, and orphan vicuñas are raised by farmers.

Vicuñas can be forced to crossbreed with alpacas, producing a fertile offspring called "paco-vicuña." The fine fiber of the vicuña becomes a bit coarser in the paco-vicuña, and the latter is less tame than an alpaca.

Physical Characteristics

The vicuña is the most distinct of the South American camelids. It is smaller in size than the alpaca, with an adult body weight of only 40 to 50 kilograms and height of about 1.5 meters[36]. Total body length (tip of nose to base of tail) varies from 1.1 to 1.9 meters (Paucar et al. 1984; Burton and Pearson 1987).

The vicuña can be distinguished from the alpaca, guanaco and llama by its smaller size, slimmer build and coloration. It is maroon-dark on top with a white belly and inner thighs. Sometimes vicuña-colored alpacas are present in domestic herds, but they can be distinguished from vicuñas by having a larger fleece and sturdier build. Small guanacos (chulengos) can be similar in size and behavior to juvenile or adult vicuñas, but typically have dark faces compared to the light faces of vicuñas.

Population Censuses

The ecological habits of the vicuña and the open visibility of the puna make it possible to use total count techniques to census and estimate populations[16;29]. These estimates have been a key aspect of programs that assess both the effectiveness of anti-poaching measures and the conservation of vicuñas. Annual censuses were started in Perú in 1969 and in Chile in 1975. Recent population estimates are 120,000 individuals in Perú, 30,000 in Bolivia, 25,000 in Chile and 23,000 in Argentina (Figure 2)[23;28;49].

Recovery and Management in Chile

In the 16th century, the total vicuña population of Peru, Bolivia, Chile and Argentina is estimated to have exceeded several million[29;16]. During the following period of European colonization, however, vicuña numbers began to decline. This decline became even more acute during the 20th century, as a result of excessive commercial hunting with guns and dogs.

By the early 1950's, vicuña numbers had fallen to around 400,000 and a census in the late 1960s showed that there were only 5,000 to 10,000 vicuñas left in Perú, and fewer than 2,000 vicuñas remaining in Bolivia, Chile and Argentina[46]. In 1970, when the national population was estimated to be as few as 500 animals, the Chilean Forestry Service[15] initiated a long-term program for vicuña conservation in Chile[13]. This program involved the creation of protected areas in the northern Chilean altiplano. The program's primary objectives were to stop poaching, to halt the illegal traffic of fiber, and to apply the Vicuña Convention[57].

Soon after the Vicuña Convention was implemented, the first ranger guards were stationed within vicuña habitat (1970-1975). Since then, yearly counts have allowed close monitoring of population recovery[22;50]. Initially, a single National Park was created in the Parinacota Province to protect the vicuña and other species. More recently, this park has been subdivided into three different management areas[22;51]. During the 1980s, the protection phase was supplemented by

research into the basic ecology and behavior of vicuñas in the wild[13;24;25] and reproductive physiology in captivity[55;58;59].

Successful population recovery has begun to shift the emphasis away from conservation towards the sustainable use of this species[45;63;37]. Several studies on the quality of vicuña fiber and potential ways to distribute the benefits of sustainable use of the vicuña have been conducted. The results of these studies led to a strategic plan for the sustainable use of the vicuña[15]. This plan anticipated that the vicuña would be used sustainably by local communities by the early 1990s[15; 57]. However, this sustainable use phase was delayed because legal aspects pertaining to the distribution of benefits to local communities could not be agreed upon [26;51].

In 1995, a new phase of research began in which the main goal was to study the physiological response of the species to management operations[4]. New aspects of sustainability were investigated, relating to the efficiency of capture methods, the effects of shearing and the consequences of exploitation on the population structure[6].

A successful sustainable use program will depend on effective communication and co-operation between different scientific disciplines (e.g. ecology, animal behavior, economics, marketing). Also, because genetic research has now revealed that the alpaca is descended from the vicuña, research findings from the study of either of these two camelids can be used to suggest avenues of management for the other.

Modern use of vicuña fiber

The vicuña, along with other South American camelids, is one member of the group of animals that produce rare fibers. Other examples include goats and rabbits which produce mohair, cashmere and angora. Internationally, vicuña fiber has been well-known in the textile industry for more than 100 years. For example, at the end of the 19th century, one of the most important mills in Scotland developed the use of the vicuña fiber and specialized in vicuña fiber processing and commercialization. During the first half of the 20th century, vicuña fiber was well established on the international market.

The American Wool Handbook (1948), described an average diameter of 13.2 microns (range 6-25 microns) for 1100 fibers measured[32;56]. The vicuña has a double-coated fleece and is one of the most valuable and highly prized sources of animal fiber[53]. The coarse fibers (i.e. guard hairs) are produced from primary skin follicles and the fine fibre (i.e. undercoat) from secondary follicles. The undercoat fibers are the commercially important part of the fleece, but require mechanical removal from the guard hair (i.e. dehairing). Vicuña fiber is highly prized because it's very fine and soft and has a high dehaired yield[12;29].

Torres (1987) estimated that a total yield of 250 g of fiber could be obtained from Vicugna vicugna mensalis by shearing every two years. If an estimated life span of 8 years in the wild is considered, a total of 1 kilo of fiber could potentially be harvested from an adult vicuña. Berger, (1963) stated that a range of between 180 to 335 g of fiber could be obtained from vicuñas every two years, and also reported a maximum yield of 335 g. The difference in reported yields for vicuñas could be a consequence of different shearing methods, as well as individual differences.

Wheller (1995) described Vicugna vicugna mensalis as having an average coat fiber length of 3.28 cm in adult animals, with the long chest hair frequently reaching up to 20 cm. The fleece fiber diameter in Vicugna vicugna mensalis is 12.52 + 1.52 microns [12; 29]. . Wheller (1995) pointed out that no similar statistics are available for Vicugna vicugna vicugna. The Chilean National Forest Corporation[15] reported 186.5 g of fleece from each vicuña (V.v. vicugna) shorn in the Chilean puna [15]. This shearing was done by a method similar to that used on sheep.

A description of fiber quality from Chilean vicuñas is presented in Table 1.

Variable	Mean	SD	Minimum	Maximum
Diameter (µ)	15.1	1.01	12.8	17.6
Medulla (%)	1.9	2.9	0	12.3
Hair (%)	2.0	1.3	0	5.9
Hair Diameter (µ)	57.4	13.9	33.0	107.0

Table 1. Fiber characteristics of vicuñas at Las Vicuñas Natural Reserve (n = 45). SD = Standard Deviation.

Fleece Part	Number	Mean	SD	Percent of Total Fleece
Front Neck (g)	8	20.75	6.92	8
Belly (g)	6	29.67	8.89	11
Legs (g)	7	23.14	6.41	9
Fleece Region (g)	16	177.63	30.69	68
Tail (g)	8	10.13	3.27	4
Total Fleece (g)	8	263	23.11	100
Staple length (cm)	25	4.88	0.7	-

(Table 2. Fleece weight and composition for juvenile male vicuñas. SD = Standard Deviation. Data from Bonacic (1996).)summarizes the main characteristics of the fleece from different body regions of the vicuña (Bonacic, 1996). The fleece showed a mean total weight of 263 + 23.1 g (n = 8 animals)

Parameter	Alpaca	Llama	Guanaco	Vicuña
Number of individuals	120	66	45	70
Diameter (µ)	25.9	22.2	19.2	15.1
SD	4.5	4	3.6	1.0
Fleece Weight (g)	2200	1500	500	263
Staple (cm)	12.1	9.5	3.9	4.88
Medulla (%)	60.5	53.3	10.4	1.9
Hair (%)	-	17.2	5.4	2.0

Table 3. Comparison of fiber characteristics in South American camelids. SD = Standard Deviation. Data from Bas et al. (1995) and Bonacic (1996).

These animals were sampled at Las Vicuñas Natural Reserve (19o S, 69 30' W). had a mean fiber diameter of 15.13 + 1.01 microns, with no significant differences between sex and age groups. The lack of difference between ages and sexes suggests that the fleece of the vicuña is highly homogeneous, especially in terms of diameter of fine fibers. The percentage of medulla was low (only 1.9% + 2.89) and similarly showed no significant difference due to sex and age. Hair diameter showed a mean value of 57.4 microns, with a maximum and minimum hair diameter of 107 microns and 33 microns respectively. Hair fibers were present as a low percentage of the fleece (1.9 % + 1.33), again, with no observable sex or age differences.

Fleece composition by body region was studied in juvenile males by Bonacic (1996). A qualitative evaluation of the fiber showed extraordinary softness and luster, although sand and seeds gave some "blurry appearance" to the fleece from the lowest parts of the body. The fleece region had small amounts of the coarser hair, easily detectable because of a darker brown color and high diameter. The fleece is compact and the fiber fineness makes it difficult to part the fibers in the fleece. The whole fleece was uniform for fiber fineness, staple length, character (crimp, staple configuration, handle) and density of fibers within the fleece (Bonacic, 1996). However, this level of uniformity changes dramatically towards the front neck region and lower parts of the body. The fleece of the tail is mainly hair and is very short, hence of very limited commercial value.

The fleece region accounted for 68%, the belly 11% and only 23% of the fleece weight was obtained from parts of the body with poor fleece quality (front neck, legs and tail)(Table 2.)[1]

Table 3. Compares the fiber quality of vicuñas with other South American camelids[4;1]. Vicuña fleece shows the smallest undercoat fiber diameter and lowest percentage of medullated fiber. This means that vicuña fleece has the finest fiber of all the South American camelid species – a fact that is highly significant in terms of the commercial value of the fiber for making textiles. However, in comparison with the alpaca, fleece weight, staple length and presence of hair are less favourable characteristics of the vicuña fleece. Fiber characteristics of vicuñas from Chile are similar to those from Perú, confirming that the vicuña fleece is the finest fiber of South American camelids.

Response of vicuñas to management

The fleece of the vicuña is the result of selection pressures exerted by a highly variable environment, that includes large daily temperature fluctuations, intense solar radiation during the day, and high winds[65;15;30]. The thick coat of the vicuña provides insulation and reduces exposure to solar radiation and drying, enabling the animal to adapt to rapid changes of temperature and wind [32]. In

addition, the long cream-colored fur on the chest serves to protect the animal from the wind and cushions the animal's body when it is resting on the ground [32].

The stress of management by humans, particularly shearing, may affect the welfare and health of vicuñas by increasing exposure to wind and low overnight temperatures in the extreme climate of the puna ecosystem. Vicuñas may therefore become susceptible to wind-chill and hypothermia. Thermoregulation in camelids is accomplished by evaporative cooling (sweating) via the "thermal window". This "thermal window" is a relatively hairless area on the ventral abdomen (the axillary space), and also on the inner thighs[2;52]. Obviously, shearing takes away from the vicuña an attribute that has survival value, and thus is likely to be disadvantageous. Nevertheless, it is not obvious just how disadvantageous shearing is, and how its negative impacts can best be mitigated by alternative protocols [8].

Management of the vicuña involves capture, handling and shearing wild individuals (Figure 3). Capture and transport combined cause changes in blood glucose, packed cell volume, cortisol and neutrophil:lymphocyte ratios within 4-6 hours following capture[8]. Creatin kinase is also affected by capture and transport, showing a peak plasma level 24 hours after capture, followed by a peak plasma level in aspartate aminotransferase four days after capture and transport. However, after 12 days in captivity, vicuñas show physiological parameters close to expected baseline values for the species (Table 4 from Bonacic et al, 2003).

Future directions in vicuña management

Two main approaches for sustainable use of South American wild camelids have been discussed[6]. The first approach stresses the need to keep vicuñas under a wild management regime for effective conservation of the species. The second approach promotes the farming of vicuñas as a new economic activity with tremendous potential not only for local communities in the altiplano, but also for private businesses elsewhere.

Currently, there is no agreement between the nations of the Vicuña Convention about the future direction the program should take. For example, Argentina promotes vicuña farming with a model based on 30 years of captive farming of vicuña (at the Abrapampa experimental station)[47]. The goal has been to develop an extensive farming system to produce fiber and to promote small captive farming units throughout the Argentine altiplano (Service 1999).

Perú favours privatized ownership of vicuñas[27] and fencing for an extensive ranching system[38]. Wild vicuñas are enclosed in extensive plots (1,000ha) and rounded up and sheared periodically (Lichtenstein et al. submitted)[28;62]. Bolivia is starting to implement a sustainable use program within local communities[42].

The policy in Chile treads the middle ground, choosing to be cautious until more detailed studies have been carried out to elucidate the long term effects that any management strategy may have on the vicuña population. To these ends, Chile continues a long-term research programme to study aspects of vicuña population dynamics, and the effects of sustainable exploitation and captive herds in extensive systems coupled with efficient anti-poaching control to promote conservation of the wild populations (Service 1999).

Regardless of the methods employed to manage the exploitation of vicuña fiber, a major potential problem is the expected profit. A current international price of US$300-800/kilo (dehaired) has been suggested as suitable value for the fiber[1;27]. However, what seems highly profitable in the short term should be assessed in the context of a high initial investment and low productivity. The whole investment appears to be high risk (G. Lichtenstein, personal communication). Any proposed move from the sustainable use of wild populations towards the captive farming of vicuña seems to increase the costs and risks to the investor, and the likelihood of any short-term profit is decreased.

Another important factor to consider is that any potential market for the fiber may be restricted and small[1]. Fashion driven markets can be highly volatile over the short term, so fluctuations in demand for the fiber may be considerable. Currently, only one European company has succeeded in buying fiber from Perú and the price has been falling since the first public auction [28].

Final Remarks

The vicuña is a species well adapted to survive in a low productive ecosystem with an extremely variable climate. Behavioral and ecological adaptations enable the vicuña to thrive in this harsh environment. Its fine fleece is a unique evolutionary adaptation that protects it from the extreme weather, but has

condemned it to be persecuted and hunted since pre-Hispanic times. Today, after an international program of conservation, vicuñas are recovering from the brink of extinction.

The vicuña program is now entering a critical stage and the future direction the program takes could lead to conflicts with the program's original objectives. The strong trend for interfering with natural populations, whether by fencing or captive-raising seems incompatible with the initial criteria of sustainable use. In ecological terms, a herding system with minimal intervention in the wild population would be the best plan to secure continued sustainable use of the species. This plan also minimizes unnecessary stress to vicuñas due to shearing.

In both cases, poaching remains one of the major threats to vicuna conservation. The lack of efficient law enforcement in a vast and harsh environment is becoming a negative factor towards the aim of sustainable use of the species. It is easier and faster to shoot a vicuna with a .22 caliber rifle than to wait for population recovery within a wildlife management system or take care of captive vicuñas after fiber collection.

To date, no captive farming regime has been shown to produce vicuña fiber profitably. While the future envisaged for the vicuña seems glowing, from eco-tourism to ranching and farming, its final fate lies in the hands of human society, both the local (original communities) and international markets. If poaching control is not effective, many years of protection and research will be in vain, and a project that was once considered a model for sustainable use will be endangered.

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If you are aware of any important scientific publications about the vicuña that were omitted from this review, or have other suggestions for improving it, please contact the author at his e-mail address: faunaaustralis@gmail.com or bona@uc.cl

Portions of this article were Co-authored by Hilary Redden, Macaulay Land Use Research Institute, Aberdeen, Scotland.

Artificial Insemination in Alpacas - references

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