

Advances in ecology and conservation of *Hippocamelus* species in South America

J. M. Smith-Flueck^{A,B,L,M}, J. Barrio^C, N. Ferreyra^D, A. Nuñez^E, N. Tomas^F, J. Guzman^G, W. T. Flueck^{A,B,L}, A. Hinojosa^H, F. Vidal^{I,L}, G. Garay^{J,L} and J. Jimenez^{K,L}

^ADeerLab, C.C. 592, Bariloche (CP8400), Argentina.

^BInstitute of Analysis of Natural Resources, Universidad Atlántida Argentina, Mar del Plata.

^CCentro de Ornitología y Biodiversidad, Sta. Rita 105, of. 202, Urb Huertos de San Antonio, Lima 33, Peru.

^DFundación Bioandina, Pasaje Trahunco 110, lote 5^a. Barrio El Oasis. San Martin de los Andes (CP8370), Neuquén, Argentina.

^EDirección General de Biodiversidad y Areas Protegidas, Ministerio de Medio Ambiente y Agua, Av. Camacho 1471, La Paz, Bolivia.

^FCalilegua National Park, Jujuy, Argentina.

^GDepartamento de Ciencias Básicas, Universidad de Concepción, Los Ángeles, Chile.

^HCorporación Nacional Forestal, Patrimonio Silvestre, Claudio Arrau 738, Chillán, Chile.

^IFundación Huilo-Huilo, Vitacura 2909 of. 1112, Las Condes Santiago, Chile.

^JParaguaya 126, Punta Arenas, Chile.

^KLaboratorio de Vida Silvestre, Universidad de Los Lagos, Casilla 933, Osorno, Chile.

^LHuemul Task Force, Scientific Committee, IUCN/SSC.

^MCorresponding author. Email: j.smith@deerlab.org

Abstract. A symposium was held for the two South American deer of the genus *Hippocamelus*: the taruka, *H. antisensis* and the Patagonian huemul, *H. bisulcus*. The taruka is recognized as *vulnerable* and the huemul as *endangered* on the IUCN red list. To reverse the current trend and prevent further imminent declines, 13 recommendations were proposed. For taruka, national recovery plans should be developed and implemented in each country it inhabits, and hunting must be managed. For huemul's lack of recovery, much still remains unknown about the causal factors and their overall significance: culpeo fox (*Pseudalopex culpaeus*) appear not to be an important mortality agent of huemul fawns, whereas habitat suitability may be the fundamental cause for the declines. Research should be conducted to better evaluate the interplay of threats and their relative importance.

Additional keywords: huemul, taruka, taruca, bisulcus, antisensis, deer, habitat suitability, nutrition, protected areas, private land, distribution, behaviour, socioecology, osteology, *ex situ*, predation, Argentina, Bolivia, Chile, Peru.

Introduction

A symposium was held for the two South American deer of the genus *Hippocamelus*: the taruka, *H. antisensis* (D'Orbigny, 1834), and the Patagonian huemul, *H. bisulcus* (Molina 1782). These two species are currently separated by 822 km. Extant taruka inhabits the high Andes with its distribution stretching from northern Peru through Bolivia to northern Chile and north-western Argentina (7°30'S to 30°S latitude), while the huemul currently is found from sea level to above treeline from central Chile to southern Patagonia on both sides of the Andes (36°S to 54°S latitude, respectively). In Chile there are no records showing presence of huemul between 37°30' and 41°30'S latitude, whereas in Argentina, the most northern population today is recorded at 40°. Both species have diminished in alarming numbers and distribution in the past century. Areas with highest human densities have witnessed

the greatest impact on the species, thus those few populations that have managed to survive are often in some of the more remote corners of South America, more often than not on mountain islands. The taruka is categorized as either *vulnerable* or *endangered* in the threatened species lists of each of the countries where it inhabits while the huemul is considered endangered in both Argentina and Chile. Moreover, the World Conservation Union – IUCN red list categorizes taruka as vulnerable and the huemul as endangered. Both species are in Appendix 1 of The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Conservation efforts are required to improve the situation of both species as most populations continue to decline and even for the few that appear to be stable, their numbers are far below levels that might safeguard them against stochastic extinction events. For huemul, knowledge still lacks in terms of the level of impact

from the threats that are assumed to be responsible for the lack of recovery. The objective of the *Hippocamelus* symposium was to present the situation of several key populations of both species and to analyse the threats, taking into account applied conservation strategies and research. In this paper we summarise the twelve presentations that formed this symposium and include recommendations that were suggested to improve the situation for both species.

Taruka

The taruka with its widespread distribution, ranging from northern Peru down to north-western Argentina, has an estimated total population size of 12,000–17,000 individuals (estimated from potential available habitat), however, many populations have become fragmented and greatly reduced in size and distribution over the last century due to hunting, destruction and occupation of its habitat. Many of the remote subpopulations are outside the means of being censused so as to improve the accuracy of population estimates. From Peruvian census data (1988) and accounts by local people, the taruka population in Peru had decreased by more than 50% since the 1960s. A similar trend was observed more recently in three Peruvian subpopulations (J. Barrio, unpublished data). Based on the regional assessment made by Barrio and Ferreyra in 2008, the taruka was re-categorized from Data Deficient to Vulnerable (www.iucnredlist.org/apps/redlist/details/10053). This symposium signifies the first time that scientists and natural resource managers, representing all four countries where the taruka resides, have come together to present the latest knowledge and make conservation recommendations. Oral presentations were given by J. Guzman, A. Nuñez, and J. Barrio on research and current advances for Chile, Bolivia and Peru, respectively, with N. Ferreyra and N. Tomas covering Argentina.

Chile (J. Guzman)

Since 1986, studies on the taruka populations in northern Chile have aimed at assessing the grouping patterns, presence of fawns and juveniles, and antler growth and development (see Sielfeld and Guzman, this issue). This research has been conducted on the western Andean slopes of two northern provinces of Parinacota and Tamarugal, approximately from 18°S to 21°S latitude, located in Regions XV and I, respectively. The distribution of the current population in Chile reaches nearly as far south as 22°S in Region II, where they inhabit the lower foothills; they are most likely absent from the more southern Region III of Atacama. The majority of individuals are found today in the Parinacota province, extending as far south as Quebrada Blanca (21°S) in the Tamarugal province. In Parinacota province, the species ranges from 2600 m to 4250 m in altitude, though they mainly occur between 3000 and 3900 m on the preferred western slopes. Since 1986 the population has suffered a dramatic decrease. Factors held responsible include: irrigation channels that isolate animals from natural water sources; further extension of fenced agricultural land; introduction of goats; and, the construction of the Arica-Tambo Quemado highway and other secondary roads where animals are often hit. The situation of the taruka populations in northern Chile is a concern. Although

Chile signed and ratified the International Convention on Biodiversity in 1994 and thereby agreed to protect 10% of each of its ecosystems, this endangered species still does not receive sufficient attention, and with no ratified protection plan in place nor a single protected area set aside for this species, its future in this country is seriously threatened.

Argentina (N. Ferreyra, N. Tomas)

The taruka, classified as endangered in Argentina (Resolution 1030/04, SAyDS), is distributed in five provinces of the north-west — Jujuy, Salta, Tucumán, Catamarca and La Rioja. Since 2001, several publications on potential distribution of the taruka have improved the knowledge on the geographic distribution of this deer in Argentina (21°30'–30°S). Over the last seven years, five taruka workshops were held in Argentina with the purpose of developing the first National Conservation Plan. A list of actions recommended include: (i) verify current and historical presence of species by conducting interviews; (ii) update maps of the species' current distribution through interviews, maps of potential habitat, and contribution of specialists; (iii) design new brochures explaining the conservation status of the species; and (iv) conduct research to improve biological and ecological knowledge of the species and to determine most beneficial educational actions to take. Additionally, an analysis on competition between horses, cattle and sheep in relation to taruka was carried out in Calilegua National Park (NP) in north-western Argentina. Identified threats included a high rate of resource utilisation from local rural communities, including overgrazing and browsing by cattle and the use of control burns to turn native brush areas into pastures and to stimulate vegetative growth of pasture vegetation. In this sector of the park, the institutional presence of national parks is rather lax, which has encouraged invasion by domestic livestock to park areas of high conservation interest. In these high-altitude Andean grasslands with headwaters and abrupt topography, several populations of taruka survive, but anthropic demands continue to negatively impact the basic resources needed by taruka. The effect of domestic animals was noticeable in shared feeding and watering areas, with its potential sanitary risk for wildlife. Resource utilisation by cattle and taruka overlapped in space and time; moreover, both species selected the same forage during the critical winter period. This study showed that taruka did not make use of forests in Calilegua National Park, and it is suspected that this population is isolated.

Bolivia (A. Nuñez)

The conservation status of taruka in Bolivia was determined generating information on its present and historical distribution, population situation and the potential threats. Interviews with rural settlers were conducted, and GIS (using climate, topography, vegetation and soil) was applied to the dataset of taruka presence to calculate a potential distribution. The survey included 302 settlers in 69 localities in the Andean mountains, in the counties of La Paz, Oruro, Cochabamba, Potosí, Chuquisaca and Tarija. The potential distribution in Bolivia covers 135,759 km², stretching from the Peruvian border (14°30'S), where they are found on both sides of the Andes, to the border with Argentina where they inhabit only the eastern

Andean cordillera (22°11'S). Taruka presence was confirmed in the puna, yungas forests, Andean dry forest, and Tucuman-bolivian forest. Within the potential distributional range, areas were further evaluated for their conservation value by considering anthropogenic factors (density of human population, nearest access to the area, fire use and deforestation) that restrict taruka to poor areas. Those areas rated with the highest conservation value occupy 43% of the potential distribution, but are highly fragmented. South-western Bolivia is the most arid region of the Bolivian Andes with isolated mountains separated by vast plains and salt pans (soils with high salinity). That could be the reasons for the absence of taruka in this region. Of the surveyed people who sometimes saw taruka, 37% indicated that currently individuals are observed less often than five years ago, while 11% and 20% mentioned seeing them in greater numbers and equally as numerous as five years ago, respectively. The rest no longer saw taruka. Taruka were observed most frequently in groups of 3 or more (46%, $n = 98$), as compared to observations of pairs or solitary individuals; the average number of individuals per group was only three individuals, in comparison to the past when groups were composed of 10 or more. People frequently observe pairs and solitary individuals, which is not common for a species using open habitats. According to local perception, the main cause for reduction of the populations of taruka is hunting (70%, $n = 106$), reported in 64% ($n = 44$) of visited localities. Taruka was considered 'endangered' due to the fragmentation of its habitat, the decrease of its populations and the assumed extinctions in 22 of the visited localities (32%), mainly as a consequence of anthropogenic factors. A high priority would be to put a national plan of action into effect aiming to remove the species from the 'endangered' list with the long-term goal to allow sustainable use. Taruka recovery will depend on multidisciplinary and inter-institutional commitment and efforts, as well as on the active participation of local communities.

Peru (J. Barrio)

Domestic ungulates increasingly use and invade even the most remote areas used by taruka in Peru and potentially compete with it for food and space. Cattle and sheep ranching are both direct and indirect threats for the taruka. Aside from the competition for space, ranching always includes the use of dogs, which kill not only hidden calves less than a month old, but also adults, especially when attacking in packs. A growing threat for taruka in Peru is illegal hunting, carried out by so called 'sport hunters', and by personnel working in mines located in taruka habitat. In the last 15 years hunters have apparently increased in the high Andes, an effect of both the disappearance of terrorist groups in the area and the increase of mining concessions along the high Peruvian Andes. A sound adaptive management approach based on a trophy hunting program, which would permit the legal harvest of a few specimens per year, might reverse this trend.

Huemul

A total population size for huemul is estimated at ~1500. The fact that this congress coincided with the bicentennial anniversaries of the founding of Chile and Argentina provided an opportunity to raise awareness of the huemul, being the sole mammal represented on the Chilean coat of arms and holding the

privileged status of National Monument in Argentina. The huemul's importance at this congress was evident by the 7 presentations on the species in this symposium plus 3 talks and 5 posters in other sessions. Even though the huemul holds high conservation priority, and calls attention as a flag and umbrella species, this hasn't been enough to reverse the downward trend towards extinction.

Factors considered potentially responsible for the huemul's demise were first listed in 1992 at the first binational reunion of Chile and Argentina to develop conservation strategies for the huemul. Nearly 20 years later, these same factors are being blamed, at varying degrees, for the lack of recovery, yet studies are lacking to verify if any of these are indeed the main culprit for the current declining trend and whether their impact is widespread throughout the distributional range or just important at local levels. Oral presentations covering the conservation status of the species over the past two to three decades were given by J. Smith-Flueck on Argentina and by A. Hinojosa, C. Saucedo and F. Vidal on *in-situ* and *ex-situ* populations, respectively, in Chile. W. Flueck, G. Garay and J. Jimenez presented results from three research projects on huemul.

Argentina (J. Smith-Flueck)

Despite receiving the highest legal protection, plus an Argentine National Conservation and Recovery Plan developed in 2001, the recovery of the Patagonian huemul has not improved in recent times, and instead many subpopulations have continued to disappear, even those within national parks. The situation is particularly grave in that subpopulations are highly fragmented and totaling only 350–600 individuals, with 60% of the herds amounting to 10 to 12 individuals each. Historical events, such as hunting by native Indians followed by colonizing Europeans, were likely responsible for huemul extinctions in more favourable habitats of ecotones and former winter ranges. Although factors held responsible for the diminishing populations – cattle ranching, dogs, exotic wildlife, illegal hunting, and disease – continue to be blamed, supportive scientific evidence is lacking. Each of these factors may play an additive role in combinations with other factors in certain populations, but are unlikely primary causes. The failure of populations to rebound today in Argentina may mainly rest on: (i) unavailability of suitable habitat, (ii) impact of exotics, and (iii) subpopulations so reduced that they are subjected to constraints of biology of small populations. Emphasis in this presentation was given to the suitability of habitat currently used by huemul. Considering other wild ungulate species, it was hypothesised that behavioural patterns, morphophysiological adaptations and population dynamics of huemul will ultimately be adjusted to forage availability, rather than being fixed traits. However, species plasticity may not suffice if the species is constrained to only a portion of its historic range where acquisition of all its basic nutritional needs are no longer possible. Lack of recovery of the species in Argentina may hinge on the loss of suitable lower elevational habitat as traditional migration behaviours no longer exists, indicating an inability of huemul to obtain the necessary nutrients – minerals such as iodine and selenium – which would be in low concentrations in the upper elevations where most huemul

populations are confined in current times. That some populations demonstrate characteristic signs of deficiency with poor antlers growth and a high prevalence of osteopathology support this hypothesis (for details, see Flueck and Smith-Flueck, this issue). To the huemul's disadvantage, conducting research on populations in Argentina has been severely hampered by bureaucracy: at the turn of the millennium, government permits were refused for a long-term funded project, which would have included *in-situ* and *ex-situ* studies using radio-telemetry, while in Chile research on more than 90 marked individuals have been being carried out, as early as the 1980s. As a consequence, no population dynamic data is yet available for Argentina. What little we do know is that Argentine populations do not appear to be increasing, and there is no evidence of recolonization. Given that well meaning conservation practices of the past 20 years have not resolved the declining trend, emphasis urgently needs to aim at also considering the nutritional ecology if we are to guarantee the species' recovery. Habitat suitability as a pivotal factor influencing the huemul's demise was discussed in the context of the role of protected and non-protected areas. Maximum protection for huemul is found within the national parks, yet law enforcement, conservation management and monitoring the subpopulations are limited by the infrastructure and funding. Argentine National Parks covering 22,618 km² in Patagonia contain only ~220 huemul or <1 individual/100 km², and their viability is doubtful. In provincial reserves, huemul and its habitat are protected by several provincial laws but management is lacking and human activities are frequently allowed under the concept of multi-use, and without knowledge of impacts. Given that private lands include traditional historic winter range in the lower valleys, landowners should be encouraged to participate in huemul conservation practices. Additional recommendations for Argentina include: (i) to increase collection of scientific data to improve management and conservation programs; (ii) to encourage studies using radio-collars; (iii) to establish adequate conservation strategies to reduce or mitigate the impact of the responsible factors, and (iv) to establish captive breeding centers to conduct research on essential issues and prepare for reintroductions. Future survival of the species may depend on the existence of functional protected areas that would include national parks, provincial parks, and private lands that provide lower elevation of the species historic range. Reintroductions should aim at placing animals in areas that would provide fertile winter range and thereby huemul could gain access once again to suitable habitat where the basic nutritional needs can be satisfied.

Chile

In Chile, the huemul has been fully protected since 1929 and was recognised as endangered since 1996. Huemul conservation has been promoted through various ongoing projects both in protected and private reserves. The first Chilean National Plan for the Conservation of Huemul, created in 2001, was revised in 2008 with the main goal to reverse the declining trend.

Populations focused on in this congress included one of the more studied ones, the Nevados de Chillan population, situated in the northern most part of the species' distributional range

between 36° and 37°30'S latitude, and separated by ~400 km from the next population. The other two populations covered in the symposium are located in the far south of Chile in the Magallanes Provincial Region: Torres del Paine National Park (NP) and the Lago Cochrane National Reserve (NR) Park. Additionally the advances of the only existing captive centre for the species, located in Huilo Huilo Reserve in Chile were presented.

Monitored populations

The Nevados de Chillán population (A. Hinojosa). The Nevados de Chillán population, although one of the better studied population remains at high risk of extinction. Conservation efforts on huemul started in this region in the 1970s through the Corporación Nacional Forestal. In the 1980s, the Comité pro Defensa de la Fauna y Flora (CODEFF) became involved with support from the Frankfurt Zoological Society. Conservation efforts have concentrated mainly on improving protection through legal agreement established with private and business land holdings regarding land use. Additionally key habitat was purchased to create new protected areas, infrastructure for wardens was improved, environmental education programs were initiated, and research was undertaken to determine diet, genetic diversity and prevalence of gastrointestinal diseases. Despite the many years given to monitor and study this population, the downward trend continues. Responding to this concern, assessments of the situation have led to government reports describing the factors most likely directly responsible for the decline: while in the past the main factors were hunting, intentional fire, and/or competition with livestock, today the low number of animals is considered the main factor hindering a recovery. Currently the population size stands at less than 40 animals separated into two groups living in a protected area totaling 560,000 ha, which consists of 88,000 ha of national protected area (Ñuble NR and Huemules del Niblinto NR and Nature Sanctuary), and the remainder being private areas under protection by a Supreme Court decree. Government officials and CODEFF are eager to make decisions that will help to reverse the situation. Due to the precariously low population size and high fragmentation between the subpopulations of this population, as well as its geographical isolation (>400 km) from the remaining populations further to the south, Chilean government officials from CONAF and SAG are currently evaluating a program to translocate individuals from donor populations in the south to a future reproduction centre with the goal to eventually reintroduce individuals into the Ñuble NR. Hinojosa also summarised results from a study on this population on gastrointestinal parasitism, which she and colleagues (M. Pérez, D. González-Acuña, R. López) presented in the poster session, where a low prevalence of 11.8% parasitism was found.

Lago Cochrane National Reserve and the future Patagonia National Park (C. Saucedo). This project in Chile aims to create a national park through the initiative of private landowners. Lago Cochrane NR, also known as the Tamango NR, in the Aisen district of Chile is home to the only population that has been monitored annually for over two decades. This population, managed by CONAF, appears to be stable. More recently, several NGOs, academic institutions and the community have

joined in huemul conservation efforts in this region. In 2004, Conservación Patagónica acquired the Valle Chacabuco ranch (780 km²) with the objective to create the future 'Patagonia National Park' (2500 km²), which would eventually link the neighbouring Lago Cochrane and Jeinimeini NR. The Lago Cochrane NR and Valle Chacabuco ranch hold an estimated 120 huemul. This new park would respond to the Chilean government's goal to improve and establish continuity of habitat available to huemul by increasing grassland, shrub and temperate forest habitats.

Huemul in ex-situ (F. Vidal). An analyses of historical accounts of *Hippocamelus* spp. under captive conditions (poster presentation by Smith-Flueck and Flueck) demonstrated the suitability of the species to captivity. Chile recently further validated this by successfully establishing the only captive breeding project in the last two decades with the main objective to reintroduce individuals to the wild in the future. The logistics of this semi-captive breeding program (begun in 2005) were discussed from captures, transport, site selection, and construction design to maintenance procedures in two centres. The first centre has grown from an initial two adults to nine individuals, with a further rehabilitated male in the other centre. The success of the current program demonstrates that huemul can do well in captivity, and wherever considered beneficial, could serve as a significant conservation tool for the recovery of the species, inclusive of a research program and reintroductions to qualified sites. For the review on the historic performance of *Hippocamelus* under captive conditions and details of the Huilo Huilo semi-captive breeding centre, see Vidal *et al.* (this issue).

Three studies backing conservation efforts

Three studies were presented on huemul in this symposium: (i) osteological comparisons of appendicular skeletons of huemul and the implications for conservation; (ii) social structure, interactions, reproduction and associated movements of the huemul; and (iii) accessing the potential role of culpeo fox (*Lycalopex culpaeus*) as a predator of huemul fawns.

(i) *Osteological comparisons of huemul skeletons with other ungulates* (W. Flueck). An osteological comparisons of appendicular skeletons of huemul and the implications for conservation was presented. Early explorers described huemul as stocky, massive and short-legged deer of mountains from observations of specimens found mainly in refuge areas, with early descriptions also reporting their rareness or near extinction. Subsequent paleontological work reinforced huemul as mountain deer based on a new fossil labelled as mountain deer which, however, has recently been declared a 'nomen nudum'. All these comparisons of huemul were done without any supporting data. Leg morphometrics of huemul and 12 other ungulates revealed that huemul cannot be associated with rock climbing species, but fall within the range of other cervids. The authors caution against the rigid application of modern huemul occurrences in interpreting past habitat use and conclude that the present empirical comparisons support many other lines of evidence that huemul existed in treeless habitat and colonised Andean forests and higher altitudes secondarily. Habitat breath of huemul is thus more like that found in other closely related *Odocoileus*,

promising tremendous new opportunities for recovery efforts (for details, see Flueck and Smith-Flueck, this issue).

(ii) *Socioecology and reproduction of huemul at Torres del Paine National Park* (G. Garay). Results were presented from a 10-year behavioural study of the huemul population at Torres del Paine NP in southern Chile, which covered a wide range of information on the socioecology of the species. This population diminished during the colonization of Europeans with their cattle at the beginning of the 1900s. In 1999, a first survey in the park produced an estimated total population size at less than 60 huemul. From 2002 to 2008, sixteen ear-tagged fawns (10 females and 6 males) were marked in the central part of sector Grey. Other individuals were distinguished by natural markings, colouring, and antler characteristics in males. Huemul movements were associated with season and reproduction cycles, and concurrent with changes in group structure; six categories of social groups were identified, with mixed-sex groups as the central unit. Some observations are worth mentioning for their conservation implication, such as age at reproductive maturity of females, a parameter used in population dynamic modelling. Notably, for 3 marked females, the first mating was when they were ~16 months of age, thus giving birth when 2-years old. Fawns were born in late October or early November, which compares with birthing period for fawns at the semi-captive reproduction centre in the Huilo Huilo Reserve. During parturition, pregnant females isolated themselves from the group and remained so for a couple of weeks following the birth of their fawn; yearlings were temporarily expelled from their natal group during this period and the resident male was seen alone. During the rut, some transient solo males tried to move into the home ranges of resident males. The family group (defined as a male and a female, with or without yearlings and/or fawns) usually remained in the same area (mean size \pm s.d.: \bar{x} = 310 ha \pm 28, n = 4), and were observed throughout the year. However, some family groups, which established summer ranges at higher grounds, migrated to lower valleys in the fall, where they remained throughout the winter. There were four associated movements: within the group home range, seasonal, reproductive, and social movements of the yearlings.

(iii) *Role of Culpeo fox predation on huemul fawns* (J. Jiménez). The culpeo fox (*Pseudalopex culpaeus*), the largest of the three native Chilean canids in the genus *Lycalopex*, is sympatric with the huemul. A study at the Lago Cochrane NR, Chile, presented on trophic and spatial ecology of culpeo fox showed no evidence for fox predation over huemul fawns after analysis of 409 fecal samples collected from November 2007 through October 2008. Among the 14,092 prey items in the samples, none corresponded to huemul remains. Not even the characteristic hairs of huemul, thereby suggesting predation or carrion feeding, were detected in the fox feces. The space use of the culpeo was studied using radio-telemetry; habitat use by huemul was estimated by direct observation of marked individuals. An analysis of syntopy showed a marked overlap between 2 culpeo and 8 lactating huemul female home ranges, but both species were not detected at close range simultaneously within days, indicating a level of avoidance, likely defined by the huemul females. This avoidance behaviour may explain the unlikely predation event of a huemul fawn by a culpeo. During the study an unsuccessful

predation event of a huemul fawn by a culpeo and active cooperative defence by the mother and another adult female was observed. Thus, there was no evidence that culpeo have preyed upon or fed on a huemul carcass of neither adults nor fawns and suggests that the culpeo is not an important mortality agent of huemul fawns as previously proposed. Further monitoring and the use of more sophisticated techniques should be used to determine the causes of fawn mortality. Irrespective of the above, there could be non-lethal indirect effects by culpeo on huemul as yet still unknown.

Conclusions

Recommendations for Hippocamelus conservation

To reverse the current trend and prevent further imminent declines, the following recommendations were proposed in the various presentations:

1. Create protected areas for huemul and taruka that will improve habitat quality, taking into account what should be the minimal size of the area to retain a viable population under the particular conditions
2. Develop protected areas for huemul on private lands that contain former winter range in the lower valleys, and moreover, those lands that can serve as corridors for seasonal migrations between summer and winter ranges through cooperation of the landowners
3. Prevent further habitat loss
4. Improve landscape connectivity between sub-populations for both taruka and huemul
5. Realise that current habitat use is not indicative of optimal suitable habitat for either of the two species, whose members have probably instead been forced to live in marginal environments from pressures by paleoindians and the colonization of the early European settlers
6. Increase knowledge on ecology and biology of the two species, such as habitat requirements, current habitat constraints, and basic reproductive parameters, while keeping in mind the potential plasticity of the species
7. Encourage long-term studies, especially those that will improve our understanding of those factors that might most be impacting the species over a wide expanse of its distributional range
8. Encourage studies using radio-telemetry transmitters
9. Develop an annual monitoring program for more populations, particularly in Argentina when it comes to the huemul, encouraging the use of the most sophisticated techniques available and accepted by the wildlife management profession whenever feasible, i.e. helicopter surveys
10. Use of more sophisticated techniques to determine causes of fawn mortality
11. Coordinate actions to assure long-term survival of the species in various regions and habitat types
12. Adopt actions recommended in the recently updated Chilean Huemul Conservation National Plan. Update the Argentine Huemul National Conservation and Recovery Plan with an evaluation, this time around, from a scientific committee as formerly recommended by all participants of the 2001 workshop, which was the first and only one organised to develop this plan

13. Develop a national conservation plan of action for the taruka for each country in which it resides, whose long-term goal would be to implement sustainable use, by applying a sound adaptive management approach.

Several presentations dealing with *Hippocamelus*, including from other sessions and posters, are published in detail in this Special Issue.

Cerda *et al.* Surgical amputation of foreleg in South Andean deer (Huemul, *Hippocamelus bisulcus*) in Coyhaique, Chile.

Flueck, Smith-Flueck. Huemul heresies: beliefs in search of supporting data. Part I. Historical and zooarcheological considerations; Part II. Biological and ecological considerations; Part III. Reproduction.

Flueck, Smith-Flueck. Osteological comparisons of appendicular skeletons: a case study on Patagonian huemul deer and its implications for conservation.

Flueck, Smith-Flueck. Red deer introduced to Patagonia. 1. Diseases and implications for native ungulates.

Flueck, Smith-Flueck. Recent advances in the nutritional ecology of the Patagonian huemul: implications for recovery.

Putman, Flueck. Intraspecific variation in biology and ecology of deer: magnitude and causation.

Sielfeld, Guzmán. Distribution, reproduction and grouping patterns in the taruca (*Hippocamelus antisensis* d'Orbigny, 1834) (Artiodactyla, Cervidae) in the extreme north of Chile.

Vidal *et al.* The Patagonian huemul (*Hippocamelus bisulcus*) under captive conditions: an historical overview.

Acknowledgements

First, our appreciation goes out to the various donors who made this symposium a reality by partially covering expenses for six of the symposium presenters to attend this congress. In Chile, much appreciation goes to the Servicio Agrícola y Ganadero, Corporación Nacional Forestal and Comisión Nacional del Medioambiente, all whom were instrumental in developing the Chilean Plan Nacional Conservación del Huemul, while in Argentina our thanks go to the National Park Administration (APN) for their role in the Argentine National Recovery Plan for Huemul. A huge thanks to those whose generous financial contribution made possible the workshops leading to these two huemul national plans: Mil Rosas S. A. and Norton S. A. for Argentina and I. Reifschneider for Chile. Government support for taruka presentations were provided by the Subsecretaría de Ambiente de la Provincia de Catamarca and the APN, and the Asociación Cinegética and the Dirección General de Fauna y Flora Silvestre in Peru. Many thanks to all those who collaborated in the presentations that formed this symposium but were unfortunately unable to attend the congress: W. Sielfeld, D. Ramadori, L. Pacheco, M. Ortega, J. Martínez-Gómez, M. C. Li Puma, P. Herrera, O. Guineo, E. Fra, P. Corti and E. Arias. Saucedo, per his request and those of his collaborators Corti and Herrera, is not included as co-author in this paper, and thus only a brief summary of his presentation is provided. This paper is dedicated to Ines Mallman, a *bona fide* huemulera while she lived, whose love of nature and enthusiastic energy during field expeditions in search of the mysterious Patagonian huemul will inspire her friends for years to come.