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## Special issue: introduction

# Research on ecology, conservation and management of wild ungulates in Mexico

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### Abstract

This special issue of Tropical Conservation Science provides a synopsis of nine of the eleven presentations on ungulates presented at the Symposium on Ecology and Conservation of Ungulates in Mexico during the Mexican Congress of Ecology held in November 2008 in Merida, Yucatan. Of the eleven species of wild ungulates in Mexico (Baird's tapir *Tapirus bairdii*, pronghorn antelope *Antilocapra americana*, American bison *Bison bison*, bighorn sheep *Ovis canadensis*, elk *Cervus canadensis*, red brocket deer *Mazama temama*, Yucatan brown brocket *Mazama pandora*, mule deer *Odocoileus hemionus*, white-tailed deer *Odocoileus virginianus*, white-lipped peccary *Tayassu pecari* and collared peccary *Pecari tajacu*), studies which concern four of these species are presented: Baird's tapir and the white lipped peccary, which are tropical species in danger of extinction; the bighorn sheep, of high value for hunting in the north-west; and the white-tailed deer, the most studied ungulate in Mexico due to its wide distribution in the country and high hunting and cultural value. In addition, two studies of exotic species, wild boar (*Sus scrofa*) and red deer (*Cervus elaphus*), are presented. Issues addressed in these studies are: population estimates, habitat use, evaluation of UMA (Spanish acronym for 'Wildlife Conservation, Management and Sustainable Utilization Units') and ANP (Spanish acronym for 'Natural Protected Areas') to sustain minimum viable populations, and the effect of alien species in protected areas and UMA, all of which allow an insight into ungulate conservation and management within the country.

**Key words:** wild ungulates, research needs, conservation, species extinction, Mexico.

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## Introduction

Ungulates include the majority of large herbivores on the planet [1]. With the exception of Antarctica, they are found in nearly all biomes and zoogeographical regions, with human intervention allowing many species to expand their original geographical boundaries. The actual number of species varies from author to author because the concept of species is flexible and is constantly changing depending on the results of genetic and taxonomic research. The most widely accepted list is that published by Wilson and Reeder [2]. In general, the Smithsonian Institute recognizes 257 species of modern ungulates. Of these, at least five species have gone extinct in the last 300 years due to anthropogenic pressures, and many other species are of critical conservation concern [1].

There are 34 species of ungulates in The Americas (hereinafter America), which represents 13.2% of the ungulate species worldwide (Appendix 1). Of these 34 species, 91% belong to the order Artiodactyla and the remainder to Perissodactyla. Cervidae is one of the most represented families within the order Artiodactyla. This family includes 19 species which correspond to 55.9% of American ungulates. *Mazama* is the most diverse cervid genus in South America, represented by seven species [3,4], however, it is also one of the least known. The families Antilocapridae and Tayassuidae are endemic to America and are represented by one and three species respectively. Other families are the Camelidae and Tapiridae. In America, these are represented by two of the four species found worldwide and three of the four species found worldwide, respectively. Another notable aspect of American ungulates is the near absence of the Bovidae, the most species diverse ungulate family (137 species, most of which are found in Africa and Asia [2]). This family is represented in America by five species, which are confined to North America. Of the 34 species of American ungulates, 10 species are restricted to the Nearctic zoogeographic region, while 22 species inhabit the Neotropical region. The remaining two species, with the largest geographical distribution in America are the white-tailed deer (*Odocoileus virginianus*) and collared peccary (*Pecari tajacu*), which inhabit very different vegetation types in the Nearctic and Neotropics [5,6].

Molecular dating suggests that the family Cervidae originated and radiated in central Asia during the Late Miocene, and that Odocoileini dispersed to North America during the Miocene/Pliocene boundary, and underwent an adaptive radiation in South America after their Pliocene dispersal across the Isthmus of Panama [7]. According to the systematic relationships and evolutionary history of Neotropical deer, at least eight ancestral forms of deer invaded South America during the late Pliocene (2.5–3 MYA), and members of the red brockets had an independent early explosive diversification soon after their ancestor arrived there, giving rise to a number of morphologically cryptic species. Deer endemic to the New World fall in two biogeographic lineages: the first one groups *Odocoileus* and *Mazama americana* is distributed in North, Central, and South America, whereas the second one is composed of South American species only and includes *Mazama gouazoubira*. This implies that the genus *Mazama* is not a valid taxon [3]. Genetic analysis revealed high levels of molecular and cytogenetic divergence between groups of morphologically similar species of brockets (*Mazama*), and suggest a polyphyletic origin. In particular, *Mazama americana* showed a striking relationship with several sequences of *Odocoileus* in contrast to that expected, since this *M. americana* (now *M. temama*) haplotype, from a Mexican origin, was not associated with several Bolivian *Mazama* sequences analyzed. This could put forward that this genera is not monophyletic. On the other hand, these Bolivian *Mazama* formed a clade with *Pudu puda* and *Ozotoceros bezoarticus*. Likely, an *Odocoileus virginianus* sequence from the Central area of Colombia showed a more strong relationship with a North American *O. hemionus* sequence than with the other *O. virginianus* sequences of Colombian origin as well. This could be explained by means of various different hypotheses. The first is the existence of common

ancestral haplotypes between both species. Another one is the reiterative hybridization among both *Odocoileus* species before the migration of *O. virginianus* from North America to South America [8].



Baird's tapir *Tapirus bairdii* (photo Eduardo Naranjo), Pronghorn antelope *Antilocapra americana* (photo Sonia Gallina), American bison *Bison bison* (photo Sonia Gallina), Bighorn sheep *Ovis canadensis* (photo Sergio Alvarez-Cárdenas).

## Ungulates in Mexico

Eleven ungulate species are found in Mexico (one Perissodactyl species and ten Artiodactyls species) [9-19], which correspond to 32.4% and 4.3% of ungulate species in America and worldwide, respectively. The Perissodactyl species is the Baird's tapir *Tapirus bairdii* (Gill, 1865), and the Artiodactyl species are: one species of Antilocapridae, the pronghorn antelope *Antilocapra americana* (Ord, 1815); two species of Bovidae, the American bison *Bison bison* (Linnaeus, 1758) and the bighorn sheep *Ovis canadensis* (Shaw, 1804); five species of Cervidae, elk *Cervus canadensis* (Erxleben, 1777), the red brocket *Mazama temama* (Kerr, 1792), the Yucatan brown brocket *Mazama pandora* (Merriam, 1901), the mule deer *Odocoileus hemionus* (Rafinesque, 1817), and the white-tailed deer *Odocoileus virginianus* (Zimmermann, 1780); and two species of Tayassuidae, the white lipped peccary *Tayassu pecari* (Link, 1795) and the collared peccary *Pecari tajacu* (Linnaeus, 1758).

It is worthy of note that at in all States of Mexico, at least one species of ungulate is found [5]. For example, five species (pronghorn antelope, bison, bighorn sheep, elk and mule deer) inhabit the Nearctic region, four species (tapir, red brocket, Yucatan brown brocket and white lipped peccary) inhabit the Neotropical region, and the remaining two species, with the widest geographical and ecological distribution (white-tailed deer and collared peccary), are found throughout almost the country. However, the areas of distribution of Mexican ungulates have declined markedly and local populations have been eradicated in some localities. The main causes are uncontrolled hunting, and the loss and fragmentation of habitat [4]. This has led to the extinction of species like the American bison and elk in Mexico [11,13], although populations of these have been reintroduced. Meanwhile, species such as the tapir, bighorn sheep, white lipped peccary and pronghorn antelope are considered in danger of extinction [9,10,12,18]. With regard to brocket deer, there is insufficient information to discern their conservation status [14,15]. The deer genus *Odocoileus* and collared peccary are not regarded as endangered and their exploitation is possible under certain restrictions and within the framework of UMA (Spanish acronym for 'Wildlife Conservation, Management and Sustainable Utilization Units') [17,19]. While the number of studies with these species has increased notably throughout the country in recent years, there are still significant gaps in our knowledge [4,20,21].



Wapiti or elk *Cervus canadensis* (photo Sonia Gallina), Red brocket deer *Mazama temama* (photo Rafael Reyna), Yucatan brocket deer *Mazama pandora* (photo Rosa María González Marín), Mule deer *Odocoileus hemionus* (photo Carlos López González).

## Purpose of special issue

In November 2008 the Symposium on Ecology and Conservation of Ungulates in Mexico was organized during the Mexican Congress of Ecology in Merida, Yucatan. The aim was to bring together researchers who are working on different groups of ungulates in the country in order to share recently gained knowledge and to define both the issues of conservation affecting the different species, and the strategies necessary to address these issues. During the event, there were eleven presentations concerning seven of the eleven species of ungulates in Mexico, in addition to two presentations on wild boar and red deer. As a result of this event, nine of the eleven presentations are extensively presented in this special issue of the journal Tropical Conservation Science. These studies, carried out in different parts of the country, address topical issues and allow readers interested in conservation and management insight into the status of this important group of mammals in Mexico.



White-tailed deer *Odocoileus virginianus* (photo Alberto González Gallina), White-lipped peccary *Tayassu pecari* (photo Alberto González Romero) and Collared peccary *Pecari tajacu* (photo Alberto González Romero).

## Implications for conservation

Based on the results of these studies, the implications for conservation differ in some aspects and agree in others, depending on the species in question. In the case of endangered species such as Baird's tapir and the white lipped peccary, Naranjo [22] and Reyna-Hurtado [23] suggest that it is crucial to maintain areas of habitat as large as possible, avoid fragmentation, increase connectivity between these areas, make plans for land use involving surrounding communities, and implement actions to reduce the hunting of these species. As for the bighorn sheep, which is a vulnerable species with permitted exploitation in special cases, Alvarez-Cardenas *et al.* [24] emphasize the importance of intermountain movement of individuals looking for suitable areas for breeding, rearing of young, feeding, water and genetic exchange, and therefore it is important to maintain and

restore habitat structural elements to enhance the connectivity between isolated populations.

Regarding the white-tailed deer, Sanchez-Rojas *et al.* [25] emphasize the importance of UMA as a complementary strategy for the conservation and sustainable use of this species in forested areas in the center of the country. Delfin-Alfonso *et al.* [26] propose a model for habitat assessment using geographic information systems in order to identify areas of conservation, management and reintroduction of white-tailed deer in central Veracruz. This model is also a methodological proposal to assess habitat in other regions of the country with similar characteristics. On the other hand, Coronel-Arellano *et al.* [27] propose to use the standardized vegetation index as a predictive variable of the density of white-tailed deer in temperate habitat sites, and emphasize the importance of this procedure as a potential tool for other areas focusing on the conservation and reintroduction of large carnivores, for which the deer are prey. The work of Mandujano and Gonzalez-Zamora [28] shows that most UMA do not have the critical size to support minimum viable populations (MVP) of white-tailed deer, while the Biosphere Reserves, Areas of Protection of Natural Resources, and Protected Areas of Flora and Fauna, are the ANP (Spanish acronym for 'Natural Protected Areas') which could potentially support the MVP of this species. They suggest a system of conservation at a regional level in which ANP and UMA are incorporated, assuming source-sink and archipelago reserve models, where connectivity can have an important role in the movement of individuals between populations.

Gallina and Escobedo-Morales [29] suggest connecting UMAs to preserve regional biodiversity and maintain the viability of wildlife populations. The introduction of exotic species, such as red deer, is an important alternative at production level but has not contributed to the conservation of native species and in many cases may have serious negative consequences. Therefore, strict control of these exotic species is necessary, as the encouragement of the use and conservation of native wildlife and the revision of the main conservation objectives of UMA. Finally, Breceda *et al.* [30] report on wild boar, an exotic species, and emphasize the potential impacts this animal may have on native species of ungulates, as they may compete for food and space and cause changes in habitat and the regeneration processes of endemic plants. Moreover, they constitute a potential threat to the biodiversity of Biosphere Reserves, which contain a significant number of endemic species. For these reasons continuous population control is necessary.

### **Species and research topics not included in this special number**

In Mexico, the bison is under special protection and the only wild population is found in a region that is under evaluation to be protected as a reserve [31]. The pronghorn antelope is an endangered species in our country but there are some stable populations in different localities [32]. Mule deer is not an endangered species but some subspecies (*O. h. cerrocensis*, *O. h. peninsulae* y *O. h. sheldoni*) have severe conservation problems [16]. There are population studies in Durango and Baja California [33-35]. The brocket deer species are not in danger but are considered fragile [14,15], there are some studies in the southeast states as Campeche, Quintana Roo, Chiapas and Tabasco [36-38]. Nevertheless there is a need to do more efforts in order to increase the knowledge of these species including their systematic, because the phylogenetic origin is not yet clear [3,7,8]. The other species not treated in this special number is the collared peccary, with a widest geographical distribution and exploited in Mexico, but with very few ecological studies [39]. Most of the information we have, has been obtained as a prey in studies related with felids [40-42].

Some topics about management and conservation of ungulates that need research efforts in a short time are:

- Analyze the use and sustainable hunting of ungulates in indigenous communities in areas with high and low hunting pressure [38,43].
- Assessing the effectiveness of the UMA for conservation and sustainable use of ungulates [44,45]. In particular, in tropical forest there is a need to look for different management strategies [46,47].
- Studies on fragmentation, sink-source models and metapopulations from a landscape perspective [48,49].
- Know about the role of ungulates in tropical habitats as structural agents on vegetation and the consequences of their absence [50].
- Genetic and distribution studies of white-tailed deer [51], mule deer [S. Ayala, personal communication] and brocket deer subspecies [3,7,8].
- Analyze the relationship about human population growing, agriculture technology, cattle ranching, habitat transformation and their effect on distribution areas of ungulate populations [52-54].

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Appendix 1. Wild ungulates living in the American continent, according to Wilson and Reeder [2]. \* Indicates species in Mexico.

<p><b>Orden Perissodactyla</b> Owen, 1848</p> <p><b>Familia Tapiridae</b> Gray, 1821</p> <p><b>Tapirus</b> Brisson, 1762</p> <ol style="list-style-type: none"> <li>1. * <i>Tapirus bairdii</i> (Gill, 1865) Baird's tapir, Central American tapir</li> <li>2. <i>Tapirus pinchaque</i> (Roulin, 1829) Mountain tapir</li> <li>3. <i>Tapirus terrestris</i> (Linnaeus, 1758) South America tapir, Brazilian tapir, lowland tapir</li> </ol>
<p><b>Orden Artiodactyla</b> Owen, 1848</p> <p><b>Familia Tayassuidae</b> Palmer, 1897</p> <p><b>Catagonus</b> Ameghino, 1904</p> <ol style="list-style-type: none"> <li>4. <i>Catagonus wagneri</i> (Rusconi, 1930) Chacoan peccary</li> </ol> <p><b>Pecari</b> Reinchenbach, 1835</p> <ol style="list-style-type: none"> <li>5. * <i>Pecari tajacu</i> (Linnaeus, 1758) Collared peccary, javelina</li> </ol> <p><b>Tayassu</b> G. Fisher [von Waldheim], 1814</p> <ol style="list-style-type: none"> <li>6. * <i>Tayassu pecari</i> G. Fisher [von Waldheim], 1814 White-lipped peccary</li> </ol>
<p><b>Familia Camelidae</b> Gray, 1821</p> <p><b>Lama</b> G. Cuvier, 1800</p> <ol style="list-style-type: none"> <li>7. <i>Lama glama</i> (Linnaeus, 1758) Llama, guanaco</li> </ol> <p><b>Vicugna</b> Lesson, 1842</p> <ol style="list-style-type: none"> <li>8. <i>Vicugna vicugna</i> (Molina, 1782) Vicuña</li> </ol>
<p><b>Familia Cervidae</b> Goldfuss, 1820</p> <p><b>Subfamilia Capreolinae</b> Brookes, 1828</p> <p><b>Alces</b> Gray, 1821</p> <ol style="list-style-type: none"> <li>9. <i>Alces americanus</i> (Clinton, 1822) American moose</li> </ol> <p><b>Blastocerus</b> Wagner, 1844</p> <ol style="list-style-type: none"> <li>10. <i>Blastocerus dichotomus</i> (Illiger, 1815) Marsh deer</li> </ol> <p><b>Hippocamelus</b> Leuckart, 1816</p> <ol style="list-style-type: none"> <li>11. <i>Hippocamelus antisensis</i> (d'Orbigny, 1834) Peruvian guemal, taruca</li> <li>12. <i>Hippocamelus bisulcus</i> (Molina, 1782) Patagonian huemul, South Andean huemul</li> </ol> <p><b>Mazama</b> Rafinesque, 1817</p> <ol style="list-style-type: none"> <li>13. <i>Mazama americana</i> (Erxleben, 1777) South American Red brocket</li> <li>14. <i>Mazama bororo</i> Duarte, 1996 Sao Paulo Bororo, small red brocket</li> <li>15. <i>Mazama bricenii</i> Thomas, 1908 Merida Brocket, Grey dwarf brocket</li> <li>16. <i>Mazama chunyi</i> Hershkovitz, 1959, Dwarf brocket</li> <li>17. <i>Mazama gouazoubira</i> G. Fisher [von Waldheim], 1814, Brown brocket</li> <li>18. <i>Mazama nana</i> (Hensel, 1872) Lesser brocket</li> <li>19. * <i>Mazama pandora</i> Merriam, 1901 Yucatan brown brocket</li> <li>20. <i>Mazama rufina</i> (Pucheran, 1851) Ecuador, Little red brocket</li> <li>21. * <i>Mazama temama</i> (Kerr, 1792) Central American, Mexican red brocket</li> </ol> <p><b>Odocoileus</b> Rafinesque, 1832</p> <ol style="list-style-type: none"> <li>22. * <i>Odocoileus hemionus</i> (Rafinesque, 1817) Mule deer</li> <li>23. * <i>Odocoileus virginianus</i> (Zimmermann, 1780) White-tailed deer</li> </ol>

<p><b>Ozotoceros</b> Ameghino, 1891  <i>Ozotoceros bezoarticus</i> (Linnaeus, 1758) Pampas deer  <b>Pudu</b> Gray, 1852                  25. <i>Pudu mephistophiles</i> (de Winton, 1896) Northern pudu                  26. <i>Pudu puda</i> (Molina, 1782) Southern pudu  <b>Rangifer</b> C. H. Smith, 1872                  27. <i>Rangifer tarandus</i> (Linnaeus, 1758) Caribou, reindeer</p>
<p><b>Subfamilia Cervinae</b> Goldfuss, 1820  <b>Cervus</b> Linnaeus, 1758                  28. * <i>Cervus elaphus</i>† Linnaeus, 1758 Red deer, wapiti, American elk</p>
<p><b>Familia Antilocapridae</b> Gray, 1866  <b>Antilocapra</b> Ord, 1818                  29. * <i>Antilocapra americana</i> (Ord, 1815) Pronghorn</p>
<p><b>Familia Bovidae</b> Gray, 1821  <b>Subfamilia Bovinae</b> Gray, 1821  <b>Bison</b> H. Smith, 1827                  30. * <i>Bison bison</i> (Linnaeus, 1758) American bison</p>
<p><b>Subfamilia Caprinae</b> Gray, 1821  <b>Oreamnos</b> Rafinesque, 1817                  31. <i>Oreamnos americanus</i> (de Blainville, 1816) Rocky Mountain goat  <b>Ovibos</b> de Blainville, 1816                  32. <i>Ovibos moschatus</i> (Zimmermann, 1780) Muskox  <b>Ovis</b> Linnaeus, 1758                  33. * <i>Ovis canadensis</i> Shaw, 1804 Bighorn sheep                  34. <i>Ovis dalli</i> Nelson, 1884 Dall's sheep</p>

† *Cervus canadensis* (Erxleben, 1777) according to other authors. For a discussion in this aspect, see Gallina and Escobedo-Morales [29] in this number.



Reproduction of artistic painting "Deer". Mixed technique on canvas, 110 x 90 cm, by Salvador Mandujano Rodríguez, 2007.