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Cranial Bone Lesions in Patagonian Huemul Deer (*Hippocamelus bisulcus*): First Description of a Neonatal Case

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Abstract

The only 350-500 remaining Patagonian huemul deer (**Hippocamelus bisulcus*****) are split into some 50 groups along 2000 km of Andes mountains. Osteopathy occurs among at least 57% of these endangered adult huemul, with 63% of these having mandibular and 100% having maxillary afflictions. We document the first-ever case of a neonate born with advanced cranial osteopathy. Surviving only three days, it was evaluated using computerized tomography. Mandibular wall perforations exposed premolar roots, which has not been described previously in other cervid neonates. This indicates that equivalent lesions found in adults may have started during fetal development likely from nutritional problems, rather than representing secondary effects from postnatal infections. Moreover, high prevalence of such cranial pathology among adults also has not been reported in other cervids. These and additional skeletal lesions would affect predator avoidance, may explain the low average age, and lack of population recovery.***

Keywords: ***Huemul, Hippocamelus bisulcus, Neonate, Pathology, Nutritional ecology, Conservation.***

1. Introduction

Huemul (*Hippocamelus bisulcus*) (Fig. 1) is the southern-most cervid, endemic to Chile and Argentina. It is the only large native herbivore currently residing mainly in cold-temperate false-beech (*Nothofagus spp*.) forest habitat [1]. Historically, huemul also inhabited tree-less areas, including Patagonian grasslands and the interconnecting foothills [2]. Early humans (indigenous and colonists) reduced their numbers to <1%, and the distribution to <50% [1]. As most

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ecotonal areas, valley bottoms and grasslands were settled by colonists with their livestock [3], it resulted in huemul becoming exterminated in those areas. Extant huemul now commonly remain only in remote areas that were unattractive for human settlement due to topography, low fertility, winter conditions, and difficulty to be accessed. By having also exterminated their migratory tradition, they remain all year in areas mainly qualifying as summer ranges [2].

Huemul have been fragmented into small and mostly isolated subpopulations, and the remaining 350-500 huemul in Argentina are dispersed in some 50 subpopulations along 2000 km of Andes mountains [1], [2]. For both countries, total numbers are roughly estimated at 1500, there are continued losses of subpopulations even within protected areas, and the status is considered critically endangered, especially in Argentina [1], [2]. This cervid living in remote subpopulations at low-density thus constrains field research efficacy. Yet skeletal remains collected between 1993-2007 provided many incidences of bone disease which contribute to morbidity: osteopathy among adults occurred in at least 57%, with affected individuals having mandibular (63%), maxillary (100%), and appendicular lesions (78%) [4]. Because of distortions, malocclusions, or loss of teeth, eating becomes more difficult and likely is painful. These lesions would affect the ability to avoid predators, possibly explaining the low average adult age (3.1 years), and lack of population recovery. Primary etiologic factors like senescence, gender, fulminating infections, congenital anomalies, parasitism or marasmus, fluorosis, and disorders of metabolic, endocrine, genetic, or neurologic origins were discarded [4].

Fig. 1. Male huemul during autumn in forest habitat (photo by authors).

Besides factors commonly suggested to prevent recovery (small subpopulation sizes, multi-host pathogens, reservoir hosts, pathogen characteristics, factors affecting transmission, climate change, livestock, etc) [5], another mayor component is habitat quality, particularly regarding nutritional quality as a fundamental etiological factor [6]. Well recognized are the effects of micro-nutrient deficiencies, by affecting body growth, skeletal development, reproduction and immunocompetence. Micro-nutrients contributing significantly to immunity include zinc (Zn), copper (Cu), manganese (Mn), selenium (Se), and iodine (I) [7], [8]. Copper deficiency increases the susceptibility to parasitic, bacterial, and viral infections, and may cause hoof and bone problems as found in cervids [7]. Deficiency of Se significantly reduces host defense, but also impairs osteometabolism [9]. Additionally, Se influences all immunological components, their responses to infections and cancer, and deficiency associates with increased incidence, severity (virulence) and/or progression of viral infections such as influenza, HIV and Coxsackie virus [10].

Osteopathology equivalent to those in Argentine huemul has been shown to co-occur with Se deficiency in Chilean huemul [11], with 73% deficient and 64% severely deficient cases, coinciding with documented Se deficient plants and livestock, including the occurrence of severe muscular dystrophy [12]. With the first-ever group of huemul captured and marked in Argentina (2017), three males and three females plus a fresh carcass showed that 86% were diseased with clinical pathophysiognomy included lameness, affected hooves, exfoliation of 2-7 incisors, other cranial osteopathologies (Fig. 2), and muscle atrophy [13]. Subsequently, three females and two males were captured and translocated to the recently established first-ever Rehabilitation and Breeding Station Shoonem for huemul in Argentina (2022). One male had already lost all incisive teeth (Fig. 2, bottom right); another male had lost both central incisive teeth with additional incisive teeth being loose and with partially exposed roots; two females had all incisive and canine teeth, but with additional incisive teeth being loose and with partially exposed roots; and a third female had lost both middle incisive teeth with additional incisives being loose. This pattern thus coincides with previous observations on adults (Fig. 2) based on bone remains and earlier live captures [4], [13].

Fig. 2. Examples of maxillomandibular pathology among huemul. a) in vivo: Loss of 4 and 8 incisive teeth (top left and bottom right). b) Postmortem: perforations and reduced bone thickness which expose tooth roots, defective keletogenesis and bone absorption, possibly exacerbated by a secondary reaction to infections.

2. Case Presentation

Here we describe a first-ever case of cranial pathology already occurring in a newborn fawn from this Breeding Station. General comparisons are also presented based on the only other complete newborn fawn which has been collected since 1990. Huemul placed in the Breeding Station of 100 ha in winter (2022) were observed repeatedly to determine behavioral changes, particularly during the parturition period. A newborn fawn was observed, but shortly after, its complete carcass was found in a curled-up position, then preserved by freezing, and subjected to computerized tomography, utilizing a GE-Discovery 710 PET/CT and MRI GE-SIGNA PET/MR 3 Tesla.

Regarding examinations of entire neonates, the only other case was a live female fawn found by hikers [14]. It remained in the typical cervid freeze, and erroneously assuming it to be abandoned, it was taken home, where it died three days later. Based on behavior and the naval scab, it was 3-5 days old when captured, and it died due to not being able to feed and the impossibility to relieve itself, as nobody knew about the necessity to stimulate defecation by touching the anal region. It weighted 6300 g at death and the anatomy of its skull is intact [14].

The fresh-born male fawn was detect in the Breeding Station on December 10, 2022, and it remained primarily in a laying position with little movements, however its frequent and types of bleating was interpreted as indicating a stressed animal [15]. Early on the 13th of December it was found dead: the total body weight was 2750 g. The tomography of the male fawn shows that its mandibles exhibit abnormal development. The labial side of the right mandible is perforated, exposing the roots of premolars P1 and P2, and also the roots of the unerupted molar M1. The lingual side shows perforations by premolar P3 and by molar M1 which also expose their roots (Fig. 3).

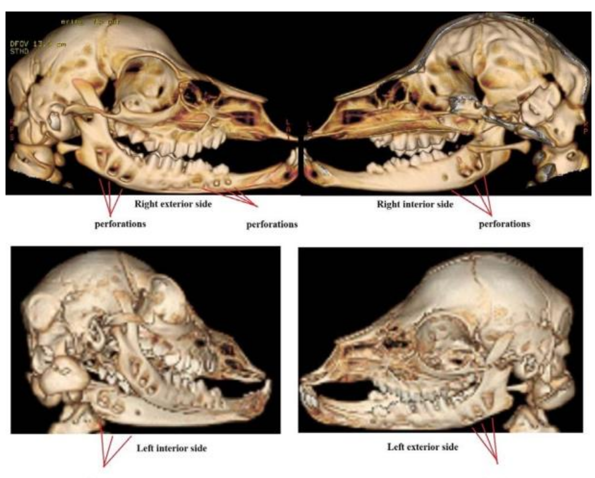

Fig. 3. Tomography of the mandible showing various perforations on labial and lingual sides. a) top: right half of mandible, b) bottom: left half of mandible. Some perforations thus expose the tooth roots on both sides of the mandibular bone.

Similarly, the left mandible has perforations on the labial side exposing the roots of at least the unerupted molar M1. The lingual side shows perforations by premolar P3 and by molar M1, exposing their roots (Fig. 3). In contrast, the skull of the fawn recovered in 1999 shows no such perforations and is considered well developed (Fig. 4).

3. Discussion

The male fawn weighted less than half as compared to the female fawn. It indicates that he was born quite small, and over a month later than another fawn born in the Breeding Station. His mother has a body size similar to the other females, she possibly conceived in the second estrous cycle, and then delivered an underdeveloped fawn. There are only two previous accounts about newborn huemul [14]. In 1949 Franke wrote about his captive huemul in the 1930s, with two fawns born [16]. He kept detailed scientific notes, but these were lost after his death, unfortunately. The other account involved a newborn fawn which died after 35 hours weighing only 2035 g. However, the mother had lost >50% body weight during a brief time in captivity and died with 32 kg shortly after her fawn died [17], suggesting that her fawn is not representative for the species.

Cranial bone lesions are symptomatic for various different causative factors. This pathophysiognomy of mandibular and maxillary bones observed in huemul has been described among other ruminants including cervids. Characteristically there are swollen jaws or cheeks and necrotic lesions which is commonly diagnosed as Lumpy jaw [18]. A major causative organism (*Actinomyces bovis*) of Lumpy jaw normally occurs as opportunist in the mouth flora of all healthy animals, and its occurrence is frequent among deer [18]. Lumpy jaw can lead to high mortality rates in fawns [18], but older animals were significantly more likely to be affected than younger ones. However, mainly individuals stressed by poor diet, especially like nutrient imbalances such as food scarcity, mineral and trace element deficiencies, or high population density and other factors, would therefore, exhibit a higher susceptibility by becoming immunodepressed. Nevertheless, wound healing in healthy individuals normally proceeds fast enough such that the infectious processes terminate soon, and without causing pathological bone remodeling. Instructively, there are no reported examples of fetal and neonatal cases of ruminants infected with *A. bovis*. A broad study of a deer population affected by *A. bovis* found no evidence in 14679 fawn jaws, and only documented cases among adults [19].

Fig. 4. Skull from the fawn recovered in 1999: no perforations on either side of the left and right mandibular bones.

Although oral pathophysiognomy in huemul could be indicative of infections as a primary problem, an alternative scenario is related to their nutritional status. Particularly mineral deficiencies involving Se, Cu and iodine are also directly involved in bone metabolism [6]. It is well established that Andean mountains have low iodine provision, have caused high frequencies of human iodine deficiencies, as well as in livestock [20]. Prenatal iodine deficiency have been described in horses, cattle, pigs, and lambs resulting in offspring being borne with congenital anomalies and frequently leading to perinatal mortality. Regarding Se, Cu and Mn, deficiencies among huemul has already been corroborated [6]. Given that such trace mineral deficiencies in the Andean regions are well documented - including in huemul, this condition must play a crucial primary role in this nutritional ecology situation.

This first report is striking in that newborn huemul already exhibits mandibular osteopathological changes compatible with those among adult cases. Although placental infections occur, neonatal bone lesions as observed here, or neonatal infections with *A. bovis* have apparently not yet been described in fetuses or newborn cervid fawns. Moreover, the sever osteopathological changes reported here would require infectious processes being in progress for substantial time, and in this case already during fetal development. However, the newborn fawn did not exhibit any symptoms of an aggravating ongoing infectious process.

4. Conclusion

This neonatal case therefore supports the interpretation that similar lesions in adult huemul may have resulted from nutritional problems starting during fetal development, rather than representing secondary effects from infections which started postpartum. The most parsimonious factor explaining the unusual pathological scenario is the anthropogenic extermination of huemul migratory traditions, resulting in permanent residency in nutritionally deficient mountain summer ranges. The ultimate cause of bone lesions in adults and this neonate certainly results in these severe cases of osteomyelitis with multifocal radiolucencies caused by rarefaction of bone. Remarkably, the high prevalence of this cranial pathology in adult huemul has not been reported in other cervids.

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