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First Endangered Huemul Deer (*Hippocamelus bisulcus*) Confirmed With Iodine Deficiency: A Case Report

Werner T Flueck[1]*, Jo Anne M Smith-Flueck[2], and Natalia Demergassi[3]

[1]National Council of Scientific and Technological Research (CONICET), Buenos Aires, Argentina

[1]Swiss Tropical and Public Health Institute, University Basel, Switzerland

[1]Fundación Shoonem, Alto Rio Senguer, Chubut, Argentina

[2]Laboratorio de Teriogenología 'Dr Héctor H. Morello', IBAC-CITAAC, Facultad de Ciencias Agrarias, Universidad Nacional del Comahue, Cinco Saltos (RN), Argentina

[2]Fundación Shoonem, Alto Rio Senguer, Chubut, Argentina

[3]Fundación Temaikèn, Belén de Escobar, Buenos Aires, Argentina

***Corresponding author**: Flueck WT, National Council of Scientific and Technological Research (CONICET), Buenos Aires, Argentina, E-mail: werner.flueck[AT]unibas.ch

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Abstract

Background: ***Huemul (Hippocamelus bisulcus) an endangered endemic cervid of Chile and Argentina, is currently confined year-round mainly to their historic summer range in the Andean mountains, with complete loss of migratory behavior due to anthropogenic activity. Trace mineral deficiencies, such as selenium and iodine, in the soils of their current year-round home range have been hypothesized to explain the lack of the species' recovery. This hypothesis has been supported by osteopathy of numerous skeletal remains, particularly in the cranium and dentary bones, with prevalent loss of teeth even at a young age. Such lesions negatively affect foraging, the ability to avoid predators, and thus contribute to the low average adult age and lack of population recovery. Low iodine levels in the Andean mountain region is causing a high frequency of associated disease in both humans and livestock. Prenatal iodine deficiency in livestock, for instance, is causing frequent perinatal mortality and neonates with congenital anomalies. Here we document results of the first-ever analysis of the iodine status in a huemul deer. Methods: Serum was used to analyze Thyrotropin via chemiluminescence immulite, Thyroxine via chemiluminescence, and Triiodothyronine via electrochemiluminescence.*** ***Results:*** ***Blood tests revealed <0,01 ng/mL for Thyrotropin, 6,9 ug/dL for Thyroxine, and 83,5 ng/dL for Triiodothyronine. Conclusions: Compared to several studies on other Odocoiline deer, the huemul was clearly deficient in iodine.***

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

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1. Introduction

Huemul (*Hippocamelus bisulcus*) (Fig. 1) is an endemic cervid in southern Chile and Argentina, with remaining deer fragmented into isolated and small subpopulations. Less than 1500 individuals remain and are split into over 100 groups along 2000 km of Andes mountains [1], [2].

Fig. 1. Huemul (*Hippocamelus bisulcus*) in autumn forest habitat.

Mineral or nutritional deficiencies have been proposed to explain the continuous lack of recovery of huemul populations. Specifically, poor population performance could be attributed to trace mineral deficiencies in their diet such as selenium and iodine; human encroachment in the lower more productive valleys and flat lands has forced the huemul to live as refugees year-round at remote upper elevations of the Andean mountain range, and thus have lost their tradition of seasonal migratory behavior [2] – [4]. This corroborates with findings of numerous skeletal remains with bone disease which contribute to morbidity. Such osteopathy occurred in at least 57% of adults involving mandibles (63%), maxilla (100%), and producing limb lesions (78%) [5]. Such osteopathic lesions negatively affect foraging, the ability to avoid predators, and thus helps explain the low average adult age of 3,1 years, and lack of population recovery [5]. In 2017 the first-ever group of huemul in Argentina was captured and marked, revealing that 86% of three males, three females plus a fresh carcass were affected by clinical pathophysiognomy including exfoliation of 2-7 incisors, other cranial osteopathologies, affected hooves, lameness, and muscle atrophy [6]. Then in 2022, the first rehabilitation and breeding center was established for huemul in Argentina (named Shoonem). Two adult males and three adult females were captured and taken to the center (all less than 5 years old): two of the females had all canine and incisor teeth, but several incisors were already loose and had partially exposed roots; the third female also had several loose incisors, with both middle incisors absent; one male had several loose incisors with gum recession and partially exposed roots, plus both central incisors missing; the other male had lost all of his incisors. These findings on live animals are consistent with the conditions seen in dead adults and captured huemul that have been examined in the past [5], [6].

The influence of selenium and iodine on pathology, particularly on the skeleton, is well documented [reviewed in 7]. Deficiency of selenium significantly reduces host defense against infections for instance, but also impairs osteometabolism [8]. Selenium deficient Chilean huemul have co-occurring osteopathology equivalent to those in Argentine huemul [9]. Of these huemul in Chile, 64% were severely deficient and another 9% were deficient, which coincides with selenium deficient plants and livestock deficiencies documented in Chile, including the occurrence of severe muscular dystrophy [10]. Also well documented, are the low iodine levels in the Andean mountain region which have caused high frequencies of human iodine deficiencies [11], [12], as well as in livestock [13]. In ruminants, the metabolism of the maternal thyroid gland is fundamental for fetal growth and development [14]. Prenatal iodine deficiency has been observed in cattle, horses, lambs and pigs, causing frequent perinatal mortality and neonates with congenital anomalies [15]. This might have been a key factor resulting in the perinatal death of the second huemul fawn born in the breeding center. The newborn male fawn weighed a mere 2750 g, which was only about 50% compared to a healthy newborn [16]. The underdeveloped fawn died on the third day and the tomography (CT scan) showed advanced cranial osteopathy [17], and a necropsy indicated other congenital problems.

The hormones thyroxine (T4) and triiodothyronine (T3) function with incorporated iodine, with thyrotropin (TSH) being a key hormone involved in their production dynamics. These hormones thus are standard components used to evaluate the iodine status in ruminants. Regarding the possible impact of iodine deficiency, there have been no studies done with huemul so far. Here we report on the first-ever case studied regarding iodine, and detected a wild huemul male being iodine deficient.

2. Materials and Methods

For this case study, we conducted the first-ever analysis of blood parameters to include the iodine status in a huemul. In mid-winter (11 Aug 2023), a single adult male was captured in the Protected Park Shoonem (Province of Chubut, Argentina). Blood was extracted from the left jugular vein, and preserved as serum. Thyrotropin (TSH) was measured via chemiluminescence immulite, Thyroxine (T4) via chemiluminescence, and Triiodothyronine (T3) via electrochemiluminescence, using an Architect ci4100 Abbott equipment.

3. Case Presentation

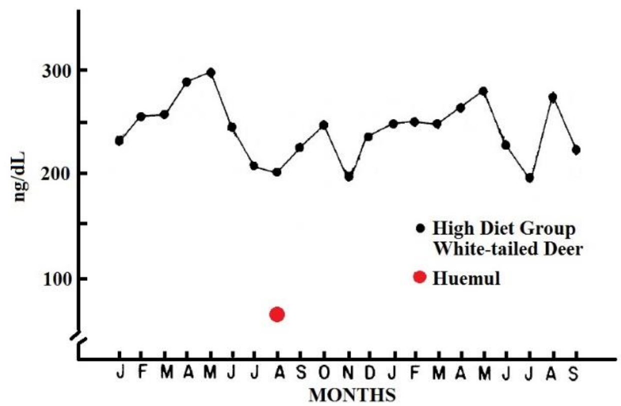
The captured male was in velvet, and although a young adult (<4 years of age) had already lost three incisors, both I1 and one I2 (Fig. 2). The blood analysis revealed concentrations of <0,01 ng/mL for TSH, 6,9 ug/dL for T4, and 83,5 ng/dL for T3 (Table 1).

Fig. 2. The male reported here had already lost three incisors, both I1 and one I2.

Table 1: Serum Concentrations of Thyroxine (T4) and Triiodothyronine (T3) in Well-Nourished and Malnourished White-Tailed Deer, in Goats with Goitre, and Compared to the Huemul Sample.

	Thyroxine (T4)	
Well-nourished white-tailed deer	17	ug/dL [18]
Well-nourished white-tailed deer	14,2	ug/dL [19]
White-tailed deer fawns, 2 winters	14,2 and 17	ug/dL, respectively [20]
Well-nourished white-tailed deer (2 years)	19-32	ug/dL [21]
White-tailed deer malnourished	9	ug/dL [18]
White-tailed deer malnourished	6,3	ug/dL [19]
Captured huemul male	6,9	ug/dL
	Triiodothyronine (T3)	
Well-nourished white-tailed deer	200-300	ng/dL [21]
Well-nourished white-tailed deer	161	ng/dL [19]
White-tailed deer malnourished	109	ng/dL [19]
Goats in Argentina with goitre	80,7	ng/dL [22]
Captured huemul male	83,5	ng/dL

When compared to another Odocoiline deer, the T4 concentration in this huemul can be considered to indicate iodine deficiency (Fig. 3). White-tailed deer (*Odocoileus virginianus*) were considered malnourished and losing much body weight when T4 reached 9 ug/dL, whereas well-nourished deer had 17 ug/dL [18]. Also, subjecting white-tailed deer to fasting in another study, they had T4 at 6,3 ug/dL with some deer dying, whereas well-fed ones had 14,2 ug/dL [19]. Many white-tailed deer fawns sampled in another population during two winters averaged 14,2 and 17 ug/dL, respectively [20]. Lastly, well-nourished white-tailed deer that were monitored monthly in another study had T4 levels of 19-32 ug/dL over two years of monitoring [21]. Additionally, also T3 levels in white-tailed deer substantiate that this huemul suffered with iodine sufficiency (Fig. 4). In one study, white-tailed deer considered malnourished showed T3 reaching 109 ng/dL, while well-nourished deer had 161 ng/dL [19]. In another study, well-nourished white-tailed deer were monitored monthly over two years, and their T3 levels were 200-300 ng/dL [21]. For goats in areas of Argentina known to have goitre, their T3 levels averaged 80,7 ng/dL [22].



Fig, 3. Monthly T4 concentrations in well-fed white-tailed deer over the course of two years [21], and the concentration of the male huemul.

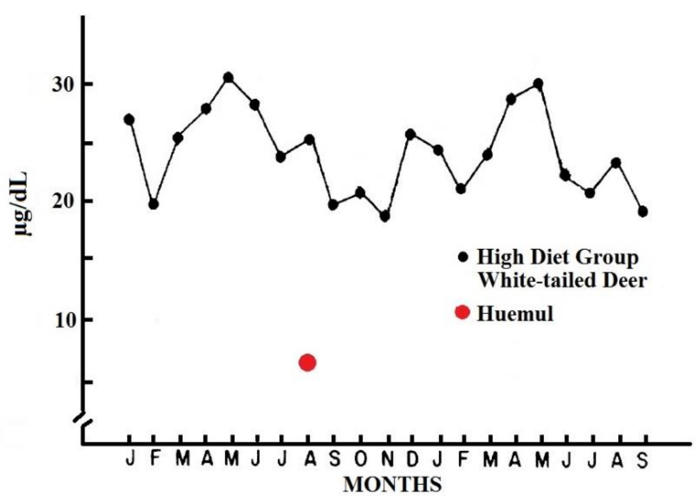


Fig. 4. Monthly T3 concentrations in well-fed white-tailed deer over the course of two years [21], and the concentration in the male huemul.

4. Discussion

The historically high prevalence of iodine deficiency has been repeatedly described for the region of the southern Andean mountain range affecting humans and their livestock [11], [12].

After losing it's tradition to migrate down to winter rages in the lowlands, the huemul is isolated far from fertile valleys and flat lands. This may be contributing to mineral deficiencies. Selenium is essential for an effective iodine metabolism, and remote areas in higher elevations frequently result in primary selenium deficiency, which secondarily will worsen iodine deficiency. The higher elevations in mountain areas commonly lead to more severe cases of selenium deficiency [23] and iodine deficiency in humans [24], with observations of their recognized pathological effects. The documented very unusual high prevalence of osteopathology among huemul, loss of teeth in early life, and perinatal problems in this study population may be the result of mineral deficiencies, particularly selenium, iodine [25], [26], copper and manganese [7].

Whereas selenium deficiency has been confirmed in huemul, the current case also supports that huemul is affected by the regional iodine dynamics combined with its current pattern of habitat use. This occurrence of combined deficiencies of several key minerals may support an explanation for the unusual pathological patterns documented among many huemul populations.

The effect of iodine deficiency in deer has also been shown to affect other skeletal parts, like their antler development. As iodine provision relates to local food and water, it was shown that the iodine content of the drinking water alone explained 51,4% of the variance of antler weights, and that their weights increase with elevated iodine concentration regardless of other factors [27]. That study also concluded that environmental iodine distribution can be a limiting factor suppressing deer performance. Trace mineral deficiency including iodine thus may also explain the poor extant antler development in huemul as compared to historic samples [28].

5. Limitations

This is a case study and the first report about iodine deficiency in this species. Although it coincides with the expected situation based on well-documented disease patterns in huemul and well-documented occurrences in this region of iodine deficiency among humans and livestock, we are considering expanding the study of the iodine situation by examining further cases in the future.

6. Conclusion

Our study shows unequivocally that wild huemul sometimes suffer from iodine deficiency based on the status of other Odocoiline deer studied. Along with that, it provides additional biochemical support to explain the prevalent osteopathological disease patterns documented for huemul, and the currently poor antler development as compared to the past. It is essential that additional huemul, and from different subpopulations, will be surveyed regarding their iodine status.

7. Author Contributions

All authors reviewed and approved the final manuscript and have contributed equally to this work.

8. Funding

This research received no external funding.

9. Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data is not publicly available due to privacy regulations.

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11. Conflicts of Interest

The authors declare no conflict of interest.

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