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Why do cervids feed on aquatic vegetation?

Francisco Ceacero[a,*], Tomás Landete-Castillejos[b,c,d], María Miranda[e], Andrés J. García[b,c,d], Alberto Martínez[f], Laureano Gallego[b,c]

[a] Department of Animal Science and Food Processing, Faculty of Tropical AgriSciences, Czech University of Life Sciences, Kamýcka 129, 165 21 Prague 6, Suchdol, Czech Republic
[b] Departamento de Ciencia y Tecnología Agroforestal y Genética, Universidad de Castilla-La Mancha (UCLM), 02071 Albacete, Spain
[c] Animal Science Tech. Applied to Wildlife Management Res. Group, IREC Sec. Albacete (UCLM-CSIC-JCCM), 02071 Albacete, Spain
[d] Sección de Recursos Cinegéticos y Ganaderos, Instituto de Desarrollo Regional (IDR), Universidad de Castilla-La Mancha (UCLM), 02071 Albacete, Spain
[e] Centre for African Ecology, School of Animal, Plant & Environmental Sciences, University of the Witwatersrand, Private Bag 3, Wits 2050, South Africa
[f] Laboratorio de Ciencia e Ingeniería de Materiales (CIMA), Instituto de Desarrollo Regional (IDR), Universidad de Castilla-La Mancha (UCLM), 02071 Albacete, Spain

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ABSTRACT

Consumption of aquatic plants is rare among cervids, despite the common occurrence of this form of vegetation. However, the paucity of literature reporting on this feeding behaviour suggests that Na (but also other minerals), protein, and the ubiquitous availability of aquatic vegetation may play a role in its consumption. We present results quantifying those factors that regulate the consumption of aquatic plants in the Iberian red deer. We focussed our study primarily on two questions: (i) what nutritional values are red deer seeking in the aquatic plants?; and (ii) why do red deer primarily use aquatic plants during the summer? A comparison of the seasonal variations in Na content between terrestrial vs. aquatic vegetation did not fully support the hypothesis that aquatic plants are being consumed more in summer because of any seasonal variation in Na availability. The Na content in the aquatic vegetation was adequate all the year-round; whereas, the Na content in the terrestrial vegetation was consistently deficient. However, a greater summer content of essential minerals and protein in the aquatic vegetation may be the cause for their consumption exclusively during the summer. We suggest that seasonal variations in the consumption of aquatic vegetation by cervids is primarily driven by temporal variations in the nutrient content, combined with seasonal variations in the physiological demands for these nutrients.

1. Introduction

Aquatic vegetation is a nutritional resource with high levels of minerals and protein, but a low fibre content (Gortner, 1934; Linn et al., 1975). It is used by a wide range of herbivores (from invertebrates to mammals; Lodge, 1991), including several species of cervids (Nowak, 1999). During the 1970s and 1980s, great interest in the use of aquatic plants by *Alces americanus* arose (Botkin et al., 1973; Jordan et al., 1973; Belovsky, 1978; Fraser et al., 1980, 1982, 1984; Belovsky and Jordan, 1981; reviewed by Jordan, 1987). Thereafter, aquatic vegetation has scarcely been considered in studies on the diet selection of cervids, even if this behaviour was repeatedly been recorded (usually only as a curiosity) for several other species such as: *Alces alces*, *Blastocerus dichotomus*, *Ozotoceros bezoarticus*, *Odocoileus hemionus*, *Odocoileus virginianus*, *Dama dama*, *Elaphurus davidianus*, *Rucervus duvaucelii*, and *Hydropotes inermis* (Nowak, 1999; Table 1). Similarly, the consumption of seaweeds has been reported in some cervids (Table 1). Thus, most of the better studied cervids have been reported to use aquatic vegetation to some extent, and therefore, the consumption of aquatic vegetation might also be expected in other cervids in which only a few (or no) studies on their diets have been conducted (e.g., *Mazama*, *Axis*, *Elaphodus*, or *Muntiacus* genera), since most of them inhabit marshy habitats (Nowak, 1999) where aquatic plants comprise a significant portion of the vegetation available.

For the European red deer (*Cervus elaphus*), the review by Gebert and Verheyden-Tixier (2001) did not include any reference to the consumption of aquatic vegetation, only a mention of the consumption of seaweeds on Rhum Island (Clutton-Brock et al., 1982; Conradt, 2000). On the Iberian Peninsula, this behaviour has been reported from the Salburua Wetland Protected Area in North Spain

* Corresponding author at: Faculty of Tropical AgriSciences, Czech University of Life Sciences, Kamýcka 129, 165 21 Prague 6, Suchdol, Czech Republic. Tel.: +420 733450473.
E-mail addresses: francisco.ceacero@outlook.com (F. Ceacero), tomas.landete@uclm.es (T. Landete-Castillejos), maria.mirandaroves@gmail.com (M. Miranda), andresjose.garcia@uclm.es (A.J. García), alberto.martinez@uclm.es (A. Martínez), laureano.gallego@uclm.es (L. Gallego).

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Table 1
Published records of consumption of aquatic-marshy vegetation or seaweeds by cervid species.

Species	Aquatic plants in diet	Location	Latitude[a]	Season	Proposed hypotheses?	Reference
Alces alces	Aquatic vegetation	Grimsö Wildlife Research Area (Sweden)	59–60° N (HL)	Summer	–	Faber et al. (1988)
Alces americanus	Aquatic vegetation	Isle Royal (Michigan, USA)	47–48° N (HL)	Spring–Summer	*'Na'*	Belovsky (1978), Belovsky and Jordan (1981), and Franzmann and Schwartz (1997)
	Aquatic vegetation	Cooke Lake (Ontario, USA)	48° N (HL)	Summer	*'Na' + 'Essential minerals' (P, Mn, Fe, Ca) + 'Protein'*	Fraser et al. (1980, 1982, 1984)
	Aquatic vegetation	Copper River Delta (Alaska, USA)	62° N (HL)	All year	*'Protein' + Supplement under food restriction*	MacCracken et al. (1993)
Blastoceros dichotomous	Aquatic vegetation	Pantanal wetland (Brazil)	19° S (T-ST)	All year	–	Tomas and Salis (2000)
	Marshy vegetation	Pantanal Natural Reserve (Brazil)	16–17° S (T-ST)	All year	–	Costa et al. (2006)
Odocoileus hemionus	Aquatic vegetation	Southern Vancouver Island (British Columbia, Canada)	48° N (HL)	All year	*Supplement under food restriction + 'Availability'*	McTaggart (1945)
	Seaweeds	Queen Charlotte Islands (British Columbia, Canada)	51–54° N (HL)	–	–	Carlton and Hodder (2003)
	Seaweeds	Tsongas National Forest (Alaska, USA)	56° N (HL)	–	–	Carlton and Hodder (2003)
	Seaweeds	San Juan Island (Washington, USA)	48° N (HL)	–	–	Carlton and Hodder (2003)
	Seaweeds	Bodega Bay (California, USA)	38° N (HL)	–	–	Carlton and Hodder (2003)
	Seaweeds	Southern Alaska (USA)		–	–	O'Clair and O'Clair (1998)
Odocoileus virginianus	Aquatic vegetation	Upper and Lower Peninsula (Michigan, USA)	45–46° N (HL)	–	*'Essential minerals' (I)*	Watkins and Ullrey (1983)
	Marshy and aquatic vegetation	Tree Islands Everglades (Florida, USA)	25° N (T-ST)	All year	–	Labisky et al. (2003)
Ozotoceros bezoarticus	Marshy vegetation	Pantanal Natural Reserve (Brazil)	16–17° S (T-ST)	All year	–	Costa et al. (2006)
	Marshy vegetation	Nhumirim (Brazil)	19° S (T-ST)	All year	–	Desbiez et al. (2011)
Rangifer tarandus	Seaweeds	South Georgia Island	53–54° S (HL)	All year	*Supplement under food restriction*	Leader-Williams (1988)
	Seaweeds	Svalbard (Norway)	79° N (HL)	Late winter	*Supplement under food restriction*	Hansen and Aanes (2012)
Axis porcinus	Aquatic vegetation (rice)	Cambodia	10–14° N (T-TS)	Rainy season	*'Availability'*	Timmins et al. (2012)
Cervus elaphus	Aquatic vegetation	Sierra de Andújar Natural Park (Spain)	38° N (HL)	–	–	Azorit et al. (2012)
	Marshy vegetation	Salburua Protected Area (Spain)	42° N (HL)	–	–	Lobo-Urrutia (2008)
	Seaweeds	Isle of Rum (Scotland, UK)	56–57° N (HL)	Winter	*Supplement under food restriction*	Conradt (2000)
Cervus nippon	Seaweeds	Primorsky Krai (Russia)	42–45° N (HL)	All year	*'Na'*	Makovkin (1999)
	Aquatic vegetation	Primorsky Krai (Russia)	42–45° N (HL)	–	*'Na'*	Aramilev (2009)
Dama dama	Aquatic vegetation	Sierra de Andújar Natural Park (Spain)	38° N (HL)	–	–	Azorit et al. (2012)
Elaphurus davidianus	Aquatic vegetation	–	–	Summer	–	Nowak (1999)
Rucervus duvaucelii	Aquatic vegetation	Royal Bardia National Park (Nepal)	28° N (T-ST)	All year	*'Na' + 'Essential minerals' (K, Ca, Mg)*	Moe (1994)
	Aquatic vegetation	Assam (India)	25–26° N (T-ST)	All year	–	Qureshi et al. (1994)
Rucervus eldii	Aquatic vegetation (rice)	Chatthin Wildlife Sanctuary (Myanmar)	23° N (T-ST)	Rainy season	*'Availability'*	McShea et al. (2001)