INTRA-INDIVIDUAL VARIATION IN CARBON AND NITROGEN ISOTOPE COMPOSITION OF BONE AND DENTIN COLLAGEN FROM MODERN WILD CAMELIDS IN THE DRY PUNA OF ARGENTINA

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Goals

The **isotopic composition** of **animal tissues** formed at different times and with different turnover rates can be used to address **dietary and physiological variation** in animal populations, especially when studying aspects such as diet **seasonality, migration and weaning** in animals from modern and archaeological contexts (Drucker *et al.* 2012). Particularly, **bone** isotopic composition reflects diet during an animal's whole life since its collagen is constantly but slowly remodeled, whereas **tooth dentin** isotopic composition reflects diet during the early years of an animal's life since its collagen does not remodel after formation (Pate and Noble 2000, Balasse *et al.* 2001).
The application of intra-individual isotopic analysis to the study of archaeological questions and past ecosystems requires a **modern reference data set**. Thus, we conducted a preliminary study of the variation in $\delta^{13}C$ and $\delta^{15}N$ values measured on **bone and dentin collagen** from a **wild South American Camelid** species (*Vicugna vicugna*) of the **Dry Puna of Argentina**.

The Vicuña


Figure 1. A vicuña.

The vicuña (Fig. 1) is adapted to **desert environments** and employs diverse habitats such as open grasslands, shrublands and wetlands (Koford 1957). The species is classified as a **generalist herbivore** with a strong selectivity towards grasses and it feeds at different plant communities on a seasonal basis (Benítez *et al.* 2006, Borgnia *et al.* 2010).
The vicuña presents a **stable social structure** composed of territorial and non-territorial animals. Territorial family groups are composed of one male, three or four females and two offspring. Non-territorial animals are solitary males and bachelor groups, composed of calves that are expelled from the family group during the new birth season (Franklin 1982). The gestation period is approximately 12 months and the calf is weaned at 8 months of age (Vilá 2000).
Vicuñas were nearly extinct in the mid-20th century. Today, as a result of protection policies, populations are recovered in most parts of the Andes (Vilá 2000).

Materials and Methods

30 vicuña skulls were collected at two different localities, **Santa Catalina** (n=17) and **Cieneguillas** (n=13), both located in the Northern portion of the Dry Puna of Argentina (Fig. 2).
Each individual was assigned to an **age class** according to **dental eruption** and **wear** patterns (Fernández Baca 1962, Oporto *et al.* 1979, Wheeler 1982, Yacobaccio *et al.* 1998) (Tab. 1, Figs. 3, 4). A **bone fragment** (from the mandible, the cranium or the atlas) and a **tooth** (incisor, canine, premolar or molar) were selected from each skull. The bone fragment and the dentin fraction of the tooth were **collagen extracted** employing the method described in Tykot (2004). **Carbon and nitrogen isotope compositions** of bone and bulk dentin collagen were measured at INGEIS (Instituto de Geocronología y Geología Isotópica, Buenos Aires, Argentina).

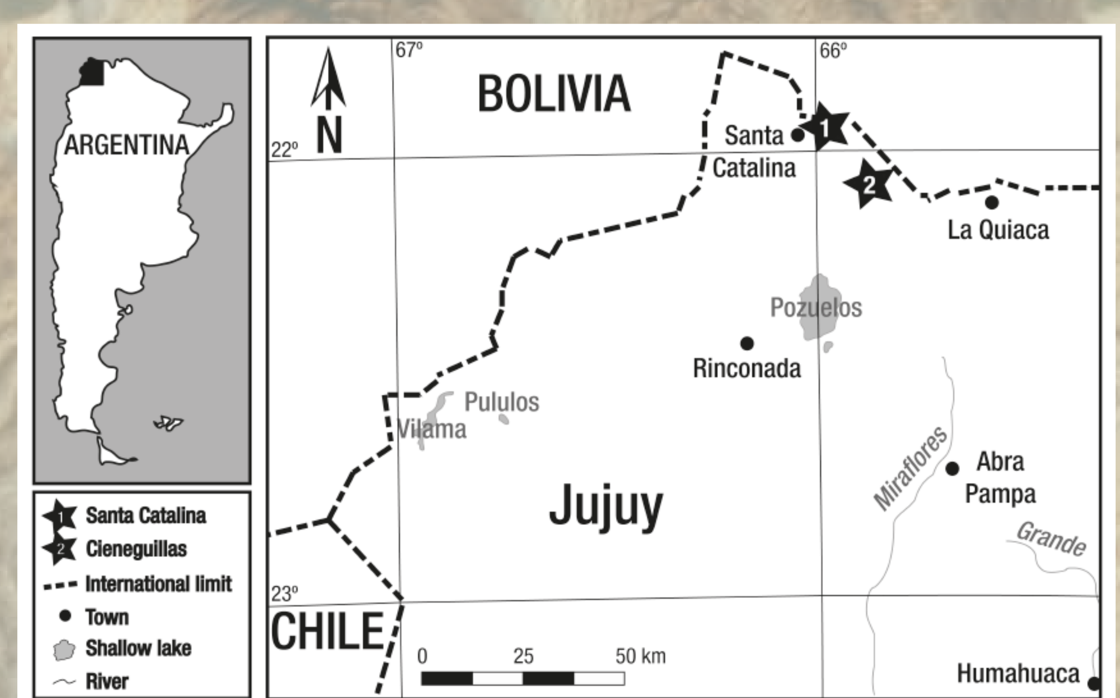

Figure 2. Sampling locations.

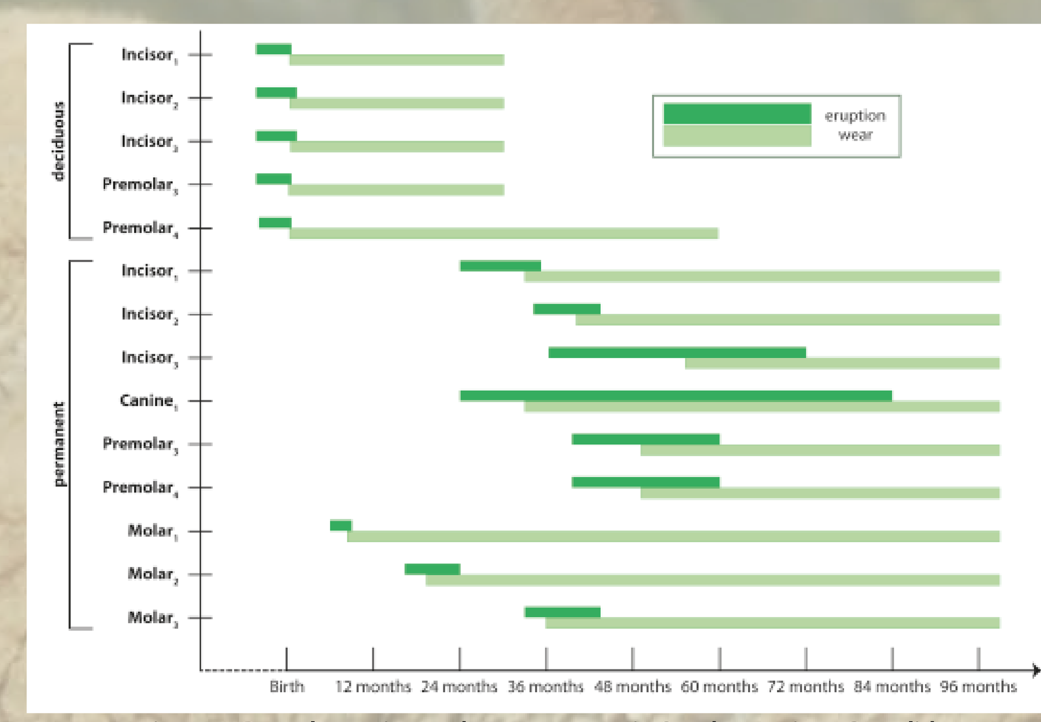

Figure 3. Dental eruption and wear patterns in South American Camelids.

All the reported results fell within the acceptable range of atomic C:N values (2.9-3.6) and ranges for %C (22.6-47) and %N (8-17.3) as expected for modern collagen (Ambrose 1990, DeNiro 1985).

Age class	Months
Newborn	< 12
Juvenile	12 - 24
Young adult	24 - 36
Adult	36 - 96
Senile	> 96

Table 1. Age clases.

Figure 4. Mandible of a juvenile.

Results

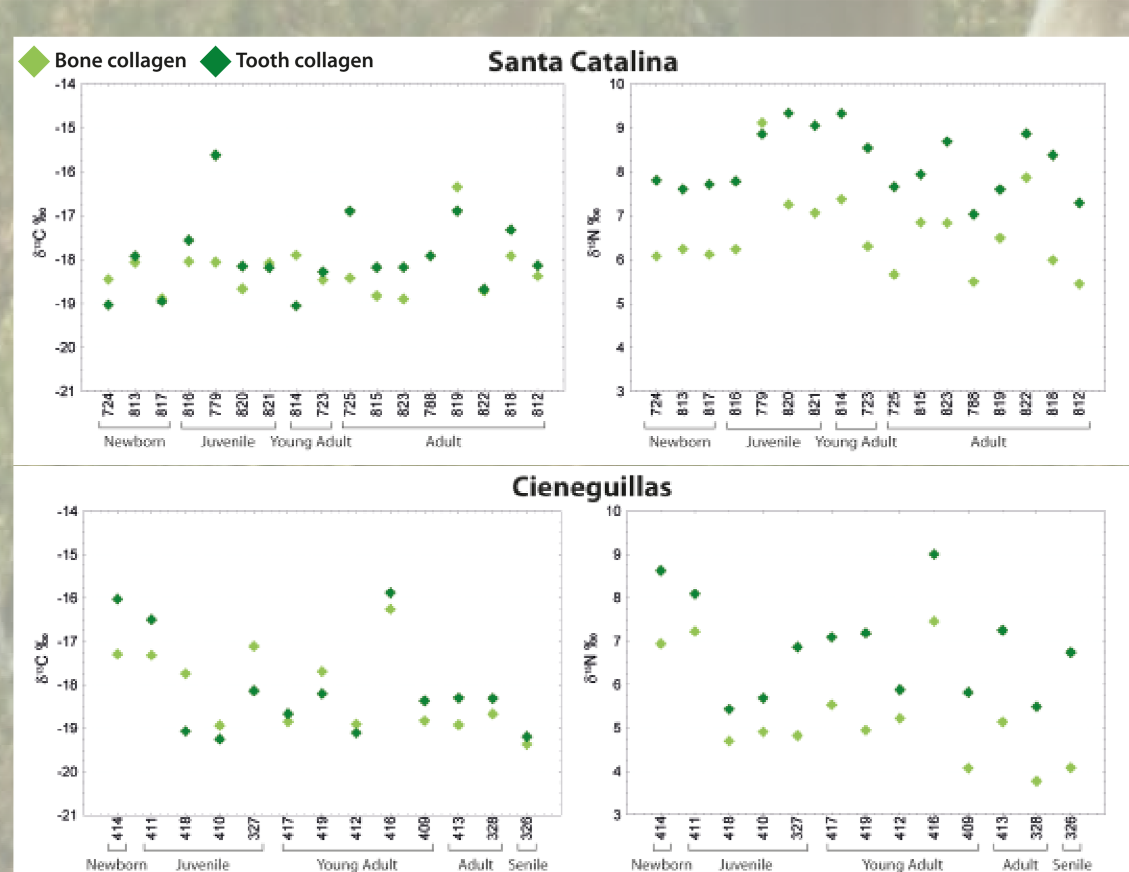

Figure 5. Differences between bone and dentine collagen isotopic compositions.

Sample	Bone	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	Tooth	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰
724	atlas	-18.5	6.1	incisor d	-19.0	7.8
813	atlas	-18.1	6.2	premolar d	-17.9	7.6
817	cranium	-18.9	6.1	premolar d	-19.0	7.7
816	cranium	-18.0	6.2	incisor d	-17.6	7.8
779	cranium	-18.1	9.1	molar 1 p	-15.6	8.9
820	cranium	-18.7	7.3	molar 1 p	-18.2	9.3
821	atlas	-18.1	7.1	incisor p	-18.2	9.0
814	atlas	-17.9	7.4	premolar d	-19.1	9.3
723	mandible	-18.5	6.3	incisor p	-18.3	8.5
725	mandible	-18.4	5.7	incisor p	-16.9	7.7
815	mandible	-18.8	6.8	incisor p	-18.2	7.9
823	cranium	-18.9	6.8	incisor p	-18.2	8.7
788	mandible	-17.9	5.5	incisor p	-17.9	7.0
819	mandible	-16.4	6.5	canine p	-16.9	7.6
822	cranium	-18.7	7.9	canine p	-18.7	8.9
818	cranium	-17.9	6.0	canine p	-17.3	8.4
812	cranium	-18.4	5.4	premolar p	-18.1	7.3
414	cranium	-17.3	6.9	incisor d	-16.0	8.6
411	cranium	-17.3	7.2	premolar d	-16.5	8.1
418	atlas	-17.7	4.7	premolar d	-19.1	5.4
410	cranium	-18.9	4.9	premolar d	-19.3	5.7
327	cranium	-17.1	4.8	molar 2 p	-18.1	6.9
417	atlas	-18.8	5.5	incisor p	-18.7	7.1
419	cranium	-17.7	5.0	incisor p	-18.2	7.2
412	mandible	-18.9	5.2	molar 2 p	-19.1	5.9
416	atlas	-16.3	7.5	molar 2 p	-15.9	9.0
409	cranium	-18.8	4.1	molar 3 p	-18.4	5.8
413	cranium	-18.9	5.1	molar 1 p	-18.3	7.3
328	cranium	-18.7	3.8	molar 2 p	-18.3	5.5
326	mandible	-19.4	4.1	molar 3 p	-19.2	6.7

Table 2. Carbon and nitrogen isotope composition of bone and dentin collagen.

$\delta^{13}C$ and $\delta^{15}N$ values of **bone** and bulk **dentin** collagen were **compared** (Tab. 2, Fig. 5).
20 of the $\delta^{13}C$ values and 29 of the $\delta^{15}N$ values measured on dentin collagen resulted more positive than those measured on bone collagen of the same animal.
The mean difference between dentin and bone collagen isotopic compositions was $\Delta^{13}C_{dentin\text{-}bone}$**=0.2 ‰** (SD=0.8) and $\Delta^{15}N_{dentin\text{-}bone}$**=1.6 ‰** (SD=0.6).
No correlation was found between age class (1= newborn, 2 = juvenile, 3 = young adult, 4 = adult, 5 = senile) and dentin isotopic composition ($\delta^{13}C$ r=-0.08 p>0.05; $\delta^{15}N$ r=-0.11 p>0.05) nor between age class and $\Delta_{dentin\text{-}bone}$ ($\Delta^{13}C_{dentin\text{-}bone}$ r=0.10 p>0.05; $\Delta^{15}N_{dentin\text{-}bone}$ r=0.28 p>0.05). No significant differences were found between deciduous (d) and permanent (p) teeth isotopic compositions ($\delta^{13}C$ U=76.5 p>0.05; $\delta^{15}N$ U=93.5 p>0.05) nor $\Delta_{dentin\text{-}bone}$ ($\Delta^{13}C_{dentin\text{-}bone}$ U=67.5 p>0.05; $\Delta^{15}N_{dentin\text{-}bone}$ U=55.5 p>0.05), neither between teeth formed before and after weaning isotopic compositions ($\delta^{13}C$ U=108 p>0.05; $\delta^{15}N$ U=98 p>0.05) nor $\Delta_{dentin\text{-}bone}$ ($\Delta^{13}C_{dentin\text{-}bone}$ U=99.5 p>0.05; $\Delta^{15}N_{dentin\text{-}bone}$ U=84 p>0.05).

Discussion and Conclusions

Our results show that **dentin collagen $\delta^{13}C$ and $\delta^{15}N$ values** are **higher** compared to **bone collagen** ones, although in some cases $\delta^{13}C$ dentin collagen values are lower than bone collagen ones, as shown by previous studies performed in other mammal species (Bocherens *et al.* 1997, Drucker *et al.* 2012). The **^{15}N enrichment** in dentin collagen relative to bone collagen is known to be a product of **suckling**, which can lead to higher $\delta^{15}N$ values in teeth formed before weaning (Fogel *et al.* 1989, Katzenberg *et al.* 1996, Fuller *et al.* 2003). Nevertheless, the results presented here did not allowed us to track the weaning process, given the **absence of a pattern** when bulk dentin collagen values measured on different age classes or different teeth (deciduous vs. permanent, pre vs. post weaning) are compared with the bone collagen values.
In conclusion, **a sequential sampling study must be performed** in order to disentangle the presence of diet changes related to weaning or seasonal variations in tooth dentin collagen. This work represents the first step towards sequential sampling of South American Camelids teeth in order to tackle diet seasonality, migration patterns and weaning in the past.

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