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Last-century changes of alpine meadows water-use efficiency – assessment by time-series analysis of the carbon isotope composition of horns of an alpine grazer *Capra ibex*

I. Barbosa (1), R. Schäufele (1), K. Auerswald (1), S. Hertwig (2), and H. Schnyder (1)

(1) Lehrstuhl für Grünlandlehre, Technische Universität München, Germany, (2) Natural History Museum of Bern, Switzerland

The ecophysiological responses of alpine meadows to recent climate change and increasing atmospheric CO_2 concentration were investigated with a new strategy to go back in time: using a time-series of *Capra ibex* horns as archives of the alpine meadows carbon isotope discrimination ($^{13}\Delta$) over the last 70 years.

From the collection of the Natural History Museum of Bern, horns of 24 animals from the population of Augsmatthorn-Brienzer Rothorn mountains, Switzerland, were sampled covering the period from 1938 to 2006. Samples were taken from the beginning of each year-ring of the horns, representing the beginning of the horn growing period, the spring.

The carbon isotopic composition (δ^{13}C) of the horns followed the decline of δ^{13}C of the atmospheric CO_2. The estimated alpine meadows $^{13}\Delta$ increased slightly (+0.3‰), though significantly ($p<0.05$), over the observation period. Estimated intercellular CO_2 concentration increased (+60 μmol mol^{-1}) less than the atmospheric CO_2 concentration (+80 μmol mol^{-1}), so that intrinsic water-use efficiency increased by 18.4 % during the 70-years period. However, atmospheric evaporative demand at the site increased by approx. 0.1 kPa between 1955 and 2006, thus counteracting the improvement of intrinsic water use efficiency. As a result, the instantaneous water-use efficiency did not change during the same period.

The observed changes in intrinsic water-use efficiency were in the same range as those of trees (as reported by others) and agreed well with the hypothesis of homeostasis of the ratio of CO_2 concentrations in leaf intercellular spaces to ambient air (c_i/c_a) under increasing ambient CO_2. This is the first reconstruction of the water-use efficiency response of a natural grassland ecosystem to last century CO_2 and climatic changes. The results indicate that the alpine grassland community has responded to climate change by improving the physiological control of carbon gain to water loss, but that effective water-use efficiency has actually remained unchanged.