

Stable isotope ecology of Miocene large mammals from Sandelzhausen, southern Germany

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Abstract The carbon, oxygen, and strontium isotope composition of enamel from teeth of large Miocene herbivorous mammals from Sandelzhausen (MN5, late Early/early Middle Miocene) in the North Alpine foreland basin, were analyzed to infer diet and habitat. The mean enamel $\delta^{13}\text{C}$ value of $-11.4 \pm 1.0\text{‰}$ ($n = 53$) for the nine taxa analyzed (including proboscideans, cervids, suids, chalicotheres, equids, rhinocerotids) indicates a pure C_3 plant diet for all mammals. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of ~ 0.710 higher than those from teeth of the western Molasse Basin (0.708–0.709) seem to indicate preferential feeding of the mammals in the northeastern Molasse Basin. The sympatric herbivores have different mean $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values which support diet partitioning and/or use of different habitats within a C_3 plant ecosystem. Especially the three sympatric rhinoceroses *Plesiaceratherium fahlbuschi*, *Lartetotherium sansaniense*, and *Prosantorhinus germanicus* show clear partitioning of plants and/or habitats. The palaeomerycid *Germanomeryx fahlbuschi* was a canopy folivore in moderately closed environments whereas *Metaschizotherium bavaricum* (Chalicotheriidae) and *P. germanicus* (Rhinocerotidae) were browsers in more closed forest environments. The horse *Anchitherium aurlanianense* was probably a more generalized feeder than assumed from its dental morphology. The forest hog

Hyotherium soemmeringi has the highest $\delta^{13}\text{C}$ and lowest $\delta^{18}\text{O}$ value of all analyzed taxa, possibly related to a frugivorous diet. Most taxa were water-dependent browsers that record meteoric water $\delta^{18}\text{O}$ values of about $-5.6 \pm 0.7\text{‰}$ Vienna Standard Mean Ocean Water (VSMOW). Using a modern-day mean annual air temperature (MAT)– $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ relation a MAT of $19.3 \pm 1.5^\circ\text{C}$ can be reconstructed for Sandelzhausen. A *Gomphotherium subtapiroideum* tusk serially sampled for $\delta^{18}\text{O}$ values does not record a clear pattern of seasonality. Thus most taxa were C_3 browsers in a forested and humid floodplain environment in the Molasse Basin, which experienced a warm-temperate to subtropical climate and possibly low seasonality.

Keywords Carbon isotopes · Oxygen isotopes · Strontium isotopes · Mean annual air temperature · Enamel · Diet · Drinking water · Molasse Basin

Kurzfassung Die Kohlenstoff-, Sauerstoff- und Strontium-Isotopenzusammensetzung von Zahnschmelzproben miozäner herbivorer Großsäuger aus Sandelzhausen (MN5, Unter-/Mittelmiozän) im nördlichen Alpenvorlandbecken wurde analysiert, um die Ernährungsweise und den Lebensraum zu rekonstruieren. Der mittlere Zahnschmelz $\delta^{13}\text{C}$ -Wert von $-11,4 \pm 1,0\text{‰}$ ($n = 53$) für die 9 analysierten Taxa (u.a. Rüsseltiere, Hirsche, Schweine, Klautiere, Pferde, Nashörner) zeigt, dass alle Säugetiere eine ausschließlich C_3 -Pflanzen basierte Ernährungsweise hatten. Die $^{87}\text{Sr}/^{86}\text{Sr}$ -Verhältnisse von $\sim 0,710$, die höher sind als von Zähne aus dem westlichen Molasse Becken (0,707–0,709), deuten auf eine bevorzugte Nahrungsaufnahme im Bereich des nordöstlichen Molasse Beckens hin. Die zeitgleich vorkommenden Herbivoren haben unterschiedliche $\delta^{13}\text{C}$ - und $\delta^{18}\text{O}$ -Werte, welche

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