δ^{15}N in lichens reflects the isotopic signature of ammonia source

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Total inorganic N (mg N m\(^{-2}\) y\(^{-1}\))

- 1860
- 1990
- 2050
Isotopes integrate, indicate, record and trace fundamental ecological processes through the isotopic fractionation (e.g. enzymes, metabolism, altitude, temperature, land-use, geographic origin).
Depleted (Lighter)  Enriched (heavier)

Why such a large range of variation?

- Differences in N sources
- $N_{MIN} (\text{NO}_3^-, \text{NH}_4^+)$
- N$_G$?
- Natural gas
- N$_2$ fixation
- Soil

Rundel et al. 1988
Stable Nitrogen Isotopes (δ¹⁵N) in Thalli of the Lichen Hypogymnia physodes along a Altitudinal Gradient in the Khangai Plateau, Mongolia

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Heathland vegetation as a bio-monitor for nitrogen deposition and source attribution using δ¹⁵N values


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Organic pollutants and their correlation with stable isotopes in vegetation from King George Island, Antarctica

Caio V.Z. Cipro, Gilvan Takeshi Yogui, Paco Bustamante, Satie Taniguchi, José L. Sericano, Rosalinda Carmela Montone
NH₃ released from a 10 m pipe at 1 m height when wind direction is 180–215° and speed is 2.5 m s⁻¹
NH₃ concentrations measured by passive samplers (ALPHA)

Two N forms: NaNO₃ and NH₄Cl
Three doses: 1, 3 and 7 times background value (8 kg N ha⁻¹ yr⁻¹)
**Xanthoria parietina**
Transplant – 10 weeks wet; 3, 6 and 10 weeks dry

**Evernia prunastri**
Transplant – 10 weeks wet; 3, 6 and 10 weeks dry

N tolerance
NO

\[
\delta^{15}\text{N} \quad \text{Total N}
\]

\[
\frac{F_{v}}{F_{m}} \quad \text{(health status index)}
\]

\[
\text{NH}_3
\]

\[
\text{NH}_4^+
\]

\[
\text{NO}_3^-
\]
Dashed line represents the estimated lichen viability threshold for Fv/Fm

Modest effect of wet deposition on *X. parietina*, with occasional decreases in few treatments; in *E. prunastri* decreased in transplants already at low doses of ammonium and nitrate, even though samples remained viable in the case of NO₃⁻.
Chlorophyll $a$ fluorescence – dry deposition

Dashed line represents the estimated lichen viability threshold for Fv/Fm

Exposure to mean concentrations of gaseous NH$_3$ equivalent to a deposition of > 1.2 kg N ha$^{-1}$ yr$^{-1}$ strongly affected photosystem II of *E. prunastri*.

*Xanthoria parietina* exhibited decreased fluorescence values only at the highest depositions of ammonia (> 4.8 kg N ha$^{-1}$ yr$^{-1}$).
A similar increase in thallus N concentration when NH$_3$ was provided to both species

For *E. prunastri*, an initial increase was followed by a decrease in total foliar N above 5 kg N ha$^{-1}$ yr$^{-1}$, which appears to be reflective of a breakdown of this species at high NH$_3$ concentrations
δ^{15}N in lichens responded to the δ^{15}N of the released atmospheric ammonia
The physiological performance of lichens (Fv/Fm) is significantly correlated with $\delta^{15}$N.
Wet deposition - NH$_4^+$

A

\[ \text{Evernia prunastri} \quad \text{Xanthoria parietina} \]

\begin{align*}
\rho &= 0.883 \\
P &= 0.020
\end{align*}

\begin{align*}
\rho &= 0.889 \\
P &= 0.018
\end{align*}

kg NH$_4^+$-N ha$^{-1}$ yr$^{-1}$

Total N (%DW)

B

\[ \text{Evernia prunastri} \quad \text{Xanthoria parietina} \]

\begin{align*}
\rho &= 0.866 \\
P &= 0.05
\end{align*}

\begin{align*}
\rho &= 0.938 \\
P &= 0.006
\end{align*}

kg NH$_4^+$-N ha$^{-1}$ yr$^{-1}$
In case of NO$_3^-$ only *E. prunastri* at the highest concentration showed a change in the isotopic signature.
Conclusion

Lichen $\delta^{15}N$ can be used as indicator of nitrogen pollution and a surrogate of nitrogen atmospheric composition. In particular, $\delta^{15}N$ in tolerant species like *X. parietina* reflects atmospheric concentration of NH$_3$. 
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Thank you for your attention!