TiP (DFG SPP 1372) Atmosphere - Ecology - Glaciology – Cluster

Suberin and Cutin as biomarkers for shifts in plant community composition following land use changes on the Tibetan Plateau

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Background

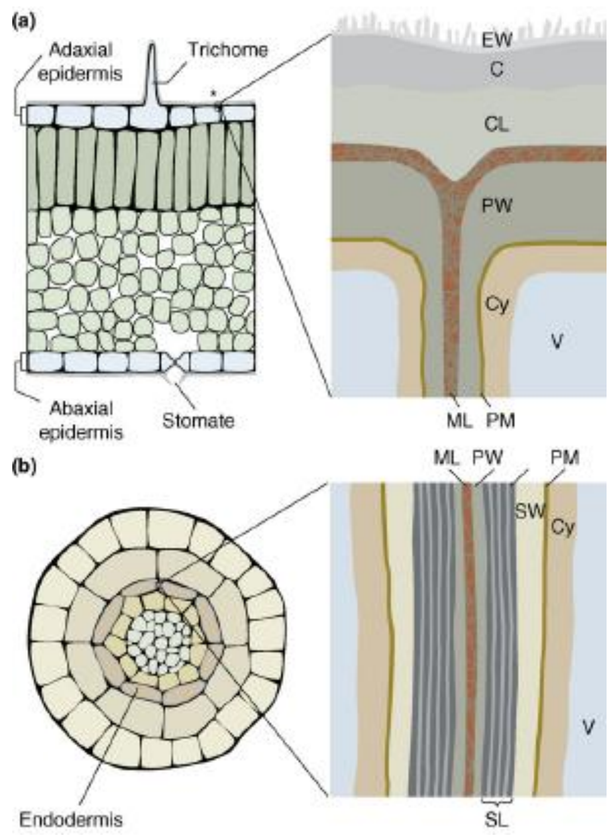
There is still a debate if the Kobresia biome on the Tibetan Plateau is human induced or climate driven. Grazing exclosure experiments show a fast replacement of Cyperaceae by Poaceae. This points to a zoo-anthropogenic influenced plant composition. We aimed to find biomarker to distinguish between different grasses and herbs dominating under different conditions.

Why Suberin and Cutin?

Suberin and cutin signatures are used as biomarkers for determining soil organic matter (SOM) sources.
Previous studies succeeded in differentiating between closely related tree species, e.g. fir (*Abies alba*), spruce (*Picea abies*) and douglas fir (*Pseudotsuga menziesii*) (Spielvogel 2010). However, signatures of different grasses and herbs have not been analyzed in detail, and it is unknown if they are identifiable in soil.

Suberin and cutin…

… are ubiquitous in plants.
… are important components of hydrophobic layers in plant cell walls.
… play in an important role as barriers controlling gas-, water-, and nutrient transport in plants.
…are characteristic for roots (suberin) and leaves (cutin), respectively.



Pollard et al. (2008)

Fig 2: Schematic of exemplarily cutin and suberin location in plants, (a) cutin deposition in leaves (EW – epicuticular waxes, C – cuticle, Cl – cuticular layer) (b) suberin deposition in roots (ML – middle lamellae, PW – primary wall, SW – secundary wall, PM – plasma membrane, Cy – cytoplasm, v – Vacuole)

Suberin

Cutin

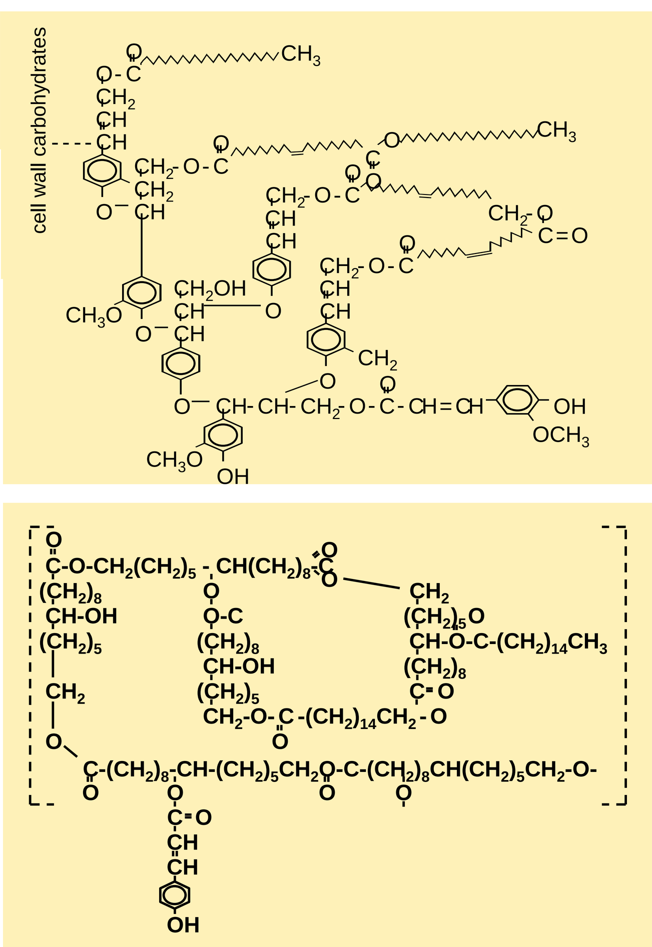


Fig 3: Example for suberin and cutin composition, respectively

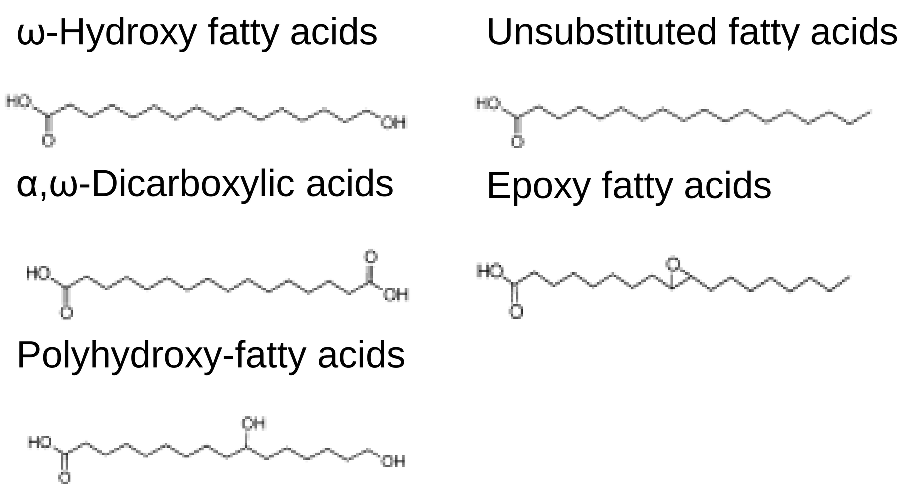


Fig 4: Examples for common suberin and cutin monomers

Method

Samples (5-20 g, depending on carbon content)

1. Extraction (double deionized water) → water soluble polar compounds
2. Extraction CH_2Cl_2, MeOH → "free lipids"

Alkaline hydrolysis:
Teflon-lined bombs 100 C / 3 h
(1 M methanolic KOH)

↓ ← Addition of internal recovery standard

Filtration, Residue:
washed (3 x) CH_2Cl_2, MeOH

↓

Acidified to pH 1 (6 M HCl) → Extraction of acidic lipids

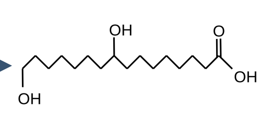
↓

Rotary evaporation; Re-dissolved:
in double deionized H_2O → Remove solvents

↓

Liquid-liquid extraction (CH_2Cl_2)

↓

Monomers: → 

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Silylation → Analyses with GC-MS

Material

- Plants and soils from *Kobresia* dominated grasslands in a montane (near Xinghai) and an alpine (north of Lhasa) area
- 20 x 20 m fences inside Yak pastures, fenced 1997 (Reting) and 2002 (Xinghai).
- Monitoring of plant community composition inside exclosures and adjacent grazed area to indicate changes in vegetation structure after fencing
- Identification of characteristic plants for both treatments
- Analysis of root and shoot samples from indicator plants: among others *Kobresia pygmaea* (Cyperaceae, grazed), *Leymus* spec. (Poaceae, ungrazed)
- Analysis of soil samples taken inside and outside the grazing excluding fences

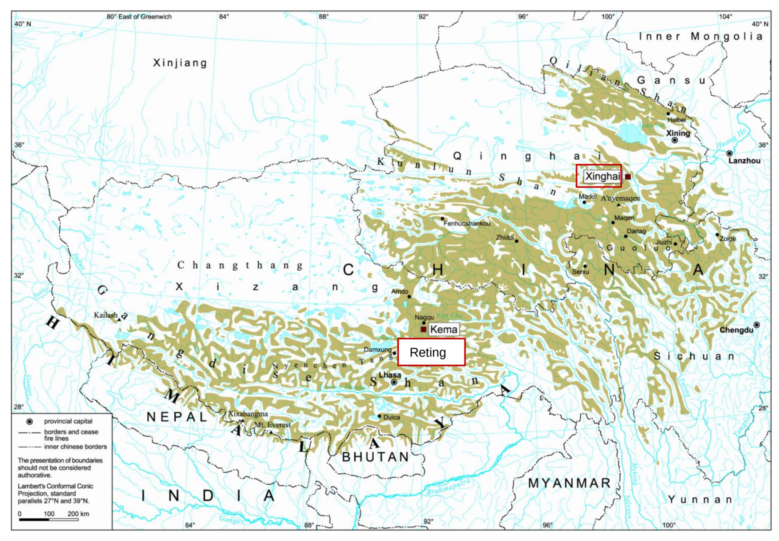

Fig 5: Distribution area of *Kobresia pygmaea* and study sides

Fig 6: *Leymus* and *Kobresia pygmaea*

Results and Discussion

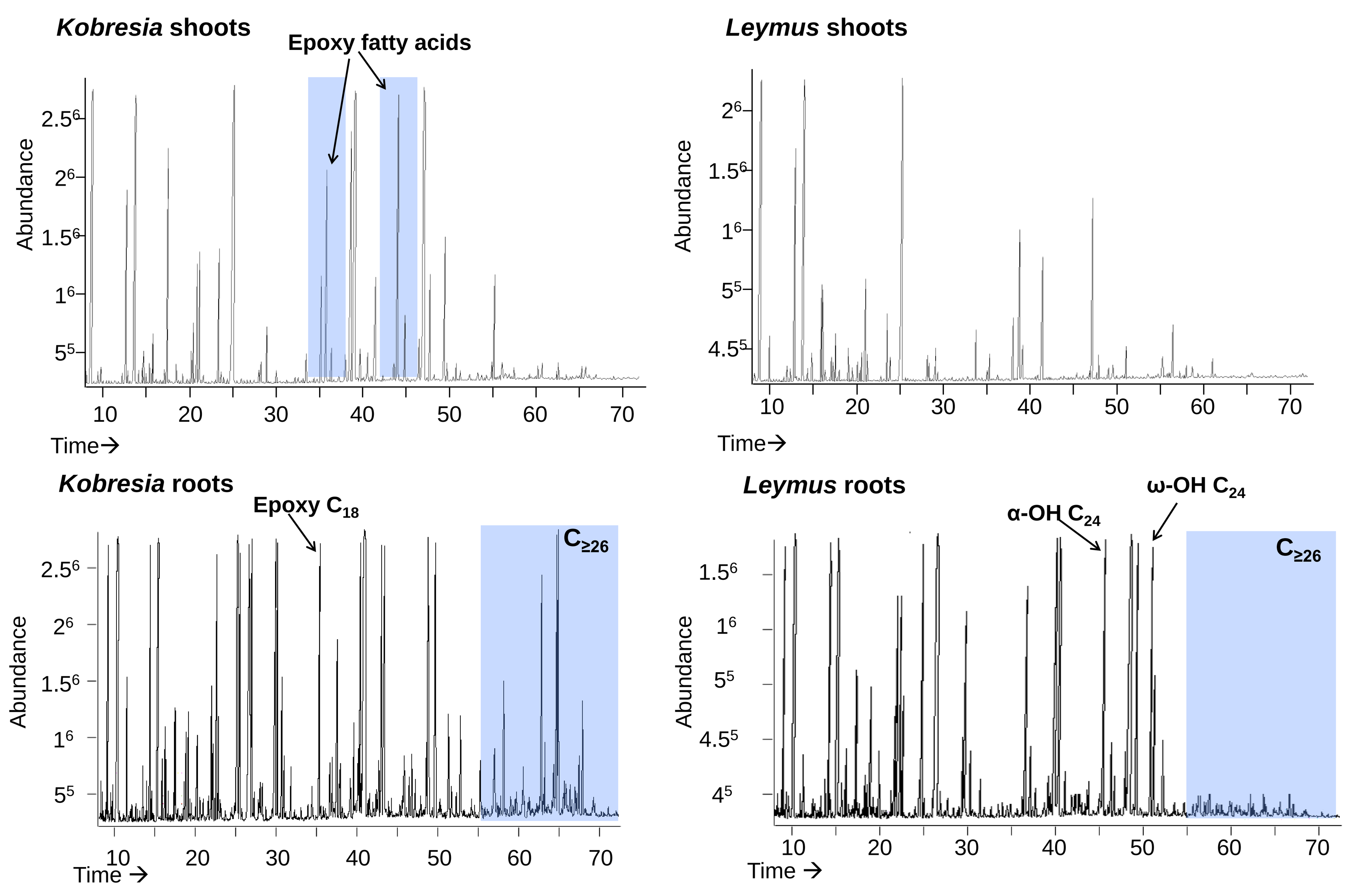

Fig 7: Chromatograms of *Kobresia* (Cyperaceae) and *Leymus* (Poaceae) – shoots and roots

- Chromatograms of plant materials show clear differences between grass species
- Signatures of roots and shoots are also different
- The suberin signature of *Kobresia* roots is characterized by several long-chain fatty acids > 26 C-atoms that are missing in Leymus roots

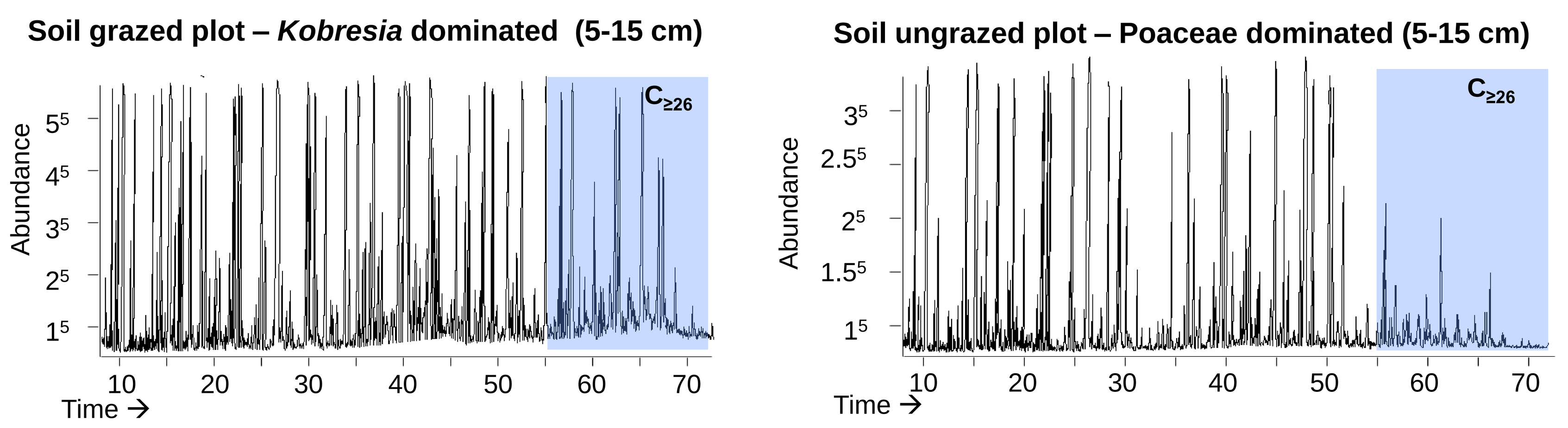

Fig 8: Chromatograms of soils sampled inside and outside the grazing excluding fence (montane area).

- Depth increment 0-5 cm (= dense root layer) mirrors root pattern
- Fatty acid signature of soils from areas of different altitude but similar vegetation did not differ
- The long-chain fatty acids signature typical for *Kobresia* roots decreased distinctly seven years after fencing
- Di-carboxylic acids seemed to have longer turnover times than ω-Hydroxy fatty acids

Conclusion

Hydrolysable aliphatic lipids derived from suberin and cutin are well suitable to distinguish between different grasses and herbs indicating diverse grazing pressure.

Cutin and suberin are compounds with a high diagnostic value for vegetation history of grasslands due to the preservation of species specific long-chain aliphatic lipids.

Reference:
Pollard M., Beisson F, Li Y., Ohlrogge J.B. (2008). Building lipid barriers: biosynthesis of cutin and suberin. Trends in Plant Science Vol 13 No. 5.
Spielvogel S., Prietzel J., Kögel-Knabner I. (2010). Lignin phenols and cutin- and suberin-derived aliphatic monomers as biomarkers for stand history, SOM source, and turn over. Geochimica et Cosmochimica Acta 74, Suppl. 1, A983-A983.

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