Short introduction to the vegetation of the „Seewinkel“/Burgenland/Austria

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Why are vegetation and flora of the „Seewinkel-area“ unique for Austria and Europe ?

There are two reasons

A. Diversity on a grand scale:

The lowland area of Seewinkel, geographically belonging to the „Small Hungarian Plan“ and characterized by the so called „Pannonian climate“, lies in the intersection of large biogeographical regions:

- Pannonian
- Illyrian (Balkan)
- Pontic
- Submediterranian
- central-European

This provides generally a broad basis of plant (and animal) taxa with diverse ecological demands.
The human cultivation - since the Neolithic until the 20 th century mostly extensively - promoted plant diversity additionally.

The hungarian term **„Puszta“** characterizes secondary, man made, open and almost treeless landscape types, wich **are the result of a longtime extensive pasturing**, based mainly on cattle farming. The extensive use provides enough space and ecological niches for many „eastern“ plant and animal species: their areals extend sometimes far east to the natural western Siberian steppic zones, and quite a lot of these species reach the westernmost edge of their expansion in the „Pannonian“ lowlands in the countries of Burgenland and Lower Austria.

The „Puszta“ harbors **many rare and beautiful plant species** and plant communities. Especially in the spring, the „Puszta“ offers aesthetically attractive and colorful aspects.

The hungarian term „Puszta“ is originally a slavic expression meaning „barren and uninhabitated land“.

To date, relicts of the originally wide-stretching „Puszta“ areas are only to find within the National Park borderlines. **Grazing** by a variety of animals (different cattle breeds, domesticated and „wild“ (Przewlsky-) horses, White donkeys) **is an important management measure** to preserve and even to restore this anthropogenic steppe landscapes.

Grazing of wetlands (including the reed belt of the Neusiedlersee), of the strand zones of saline ponds and wet saline or non-saline soils is additionally very important **to limit excessive growth of reed**, which otherwise would replace the rare hygrophytic and halophytic plant communities.

Depending on sediment and soil types, salinity, humidity, and nutrient status, the „Puszta-steppes“ vary substantially in their vegetation structure and plant species composition from site to site.


Green-winged orchid - Kleines Knabenkraut
Anacamptis (Orchis) morio


Bee orchid - Bienen-Ragwurz
Ophrys apifera

Austrian flax -Österreichischer Lein – *Linum austriacum*

Echtes Labkraut – *Galium verum* (yellow)
Esparsetten-Tragant – Astragalus onobrychis (dark violet)


Tuberous vetchling - Knollen-Platterbse
Lathyrus tuberosus


Austrian clary - Österreichischer Salbei
Salvia austriaca


Raw milkvetch – Rauer Tragant
Astragalus asper

Dyer‘s greenweed - Färber-Ginster – *Genista tinctoria* (yellow)
and Esparsetten-Tragant – *Astragalus onobrychis* (dark violet)


Spiny restharrow - Dorn-Hauhechel
Ononis spinosa

B. Diversity on a small scale

The different combination of three ecological factor-groups: „**salinity** (low, medium, high)“, „**water**“ (dry, medium, wet), and „**substrate**“ (clay, silt, sand, rubble,….) with regard to quality and quantity results in a multifaceted and from site to site **varying landscape and vegetation mosaic**, which characterizes almost the whole area of the „Seewinkel“. Somtimes varying within a few decimeter and even centimeter altitude of the soil profile, this mosaic provides a **high number of „microhabitats“,** including „extreme habitats“, if one of the mentioned facors is extremely dominating. Consequently, many plant and animal species with quite different ecological demands find their ecological niches.

…and last not least: the differently used farmland privides additional stones to this delicate landscape mosaic.

Vegetation on sandy soils

The most extended sandy habitats are situated along the so called **„Seedamm“ – „lake dam“** – which probably is the result of wind powered „ice-pushes“ („Eisstöße“), along the eastern shoreline. The sandy dam - often anthropogenic disturbed or interrupted – generally reaches from the northern edge of the Neusiedlersee until the so called „Sandeck“ south of Illmitz.

Because of he occurrence of rare and obligatory sand-bound plant and animal species, these sandy flats are especially valuably mosaic stones within our area!

Prickly Saltwort
Kali-Salzkraut
Salsola kali

from central
Asian steppes

The sandy „Seedamm“ – „lake dam“ – near Albersee, with a rare „field gromwell“ (Acker-Steinsame) subspecies: *Buglossoides incrassata*

Andrzejowski-Goldlack – A.- wallflower
Erysimum andrzejowskianum

Französischer Bockshornklee – hairy medick – *Trigonella monspeliaca*

Zwerg-Schneckenklee
Dwarf medick – *Medicago minima*

Kelch-Steinkraut
small alison (madwort)
Alyssum alyssoides

Sand-Wegerich
Sand plantain
Plantago arenaria

Sand catchfly - Kegel-Leimkraut
Silene conica

a very endangered species, near extinction!

Feather grass - Federgras
Stipa sp.

The high salt levels of soils and saline ponds (Salzlacken) have the same source:

* **Saline deposits** of the tertiary „Parathetis“, a huge saline inland sea with its shoreline just in the reach of the emerging Alps and drying out about 30 Million years ago.

* **Tectonic disturbances** in connection with the upfolding of the alpine mountain system caused allowed upward transport of deep groundwater, contaminated by the above mentioned salt depositions; thus, the ground water tables in the superficial soil layers were also contaminated with salt ions, mainly chloride, sulfate, hydrogencarbonate/carbonate, sodium and magnesium.

* The salt ions within the groundwater were continuousely absorbed by the fine-grained clay and silt sediments. Consequently, so called **„salt accumulation horizons“** in the upper soil layers were developed, crossing the area like a mosaic.

* Mainly due to the presence of many artesian wells in the Seewinkel and vicinity, there is evidence, that the **upstream salt transport** from the depth via vertical tectonic faults **is still in progress.**

* Last not least, **the pannonian climate with its hot and dry periods during late spring and summer** also contributes to the salinization of the superficial soil layers: at least for some weeks or month with – summa summarum - more evaporation than precipitation, the saline groundwater moves capillary upward, evaporates on the soil surface forming thereby the so called **„Sodaschnee“** as whitish **„salt bloomings“** („Salzausblühungen“).

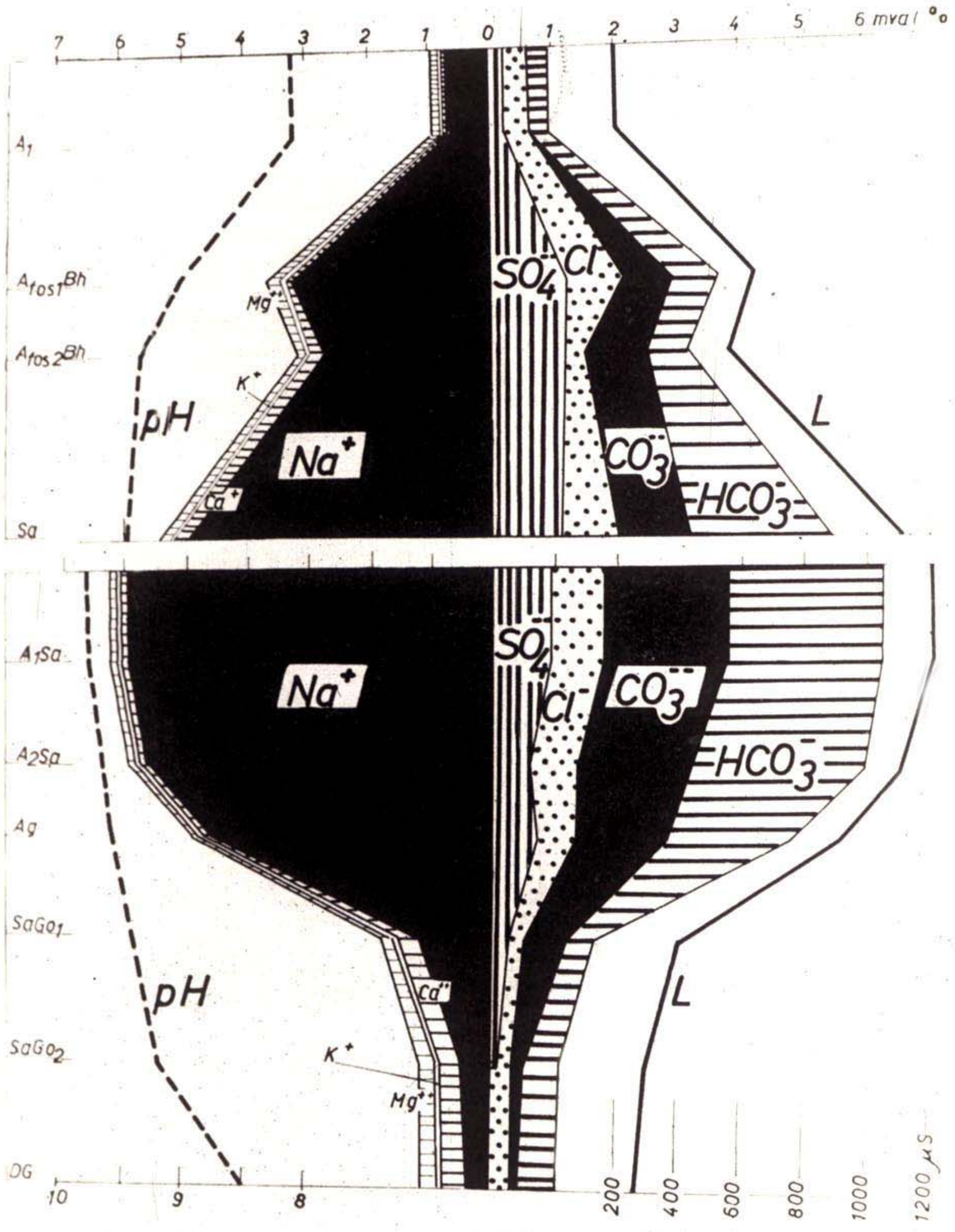
A special treasure of our area are the **soda lakes** (or soda ponds, salt pond, salt lakes) (Salzlacken, Sodalacken) and – often in direkt connection with these ponds - the **saline soils**. plant and animal communities living in these saline habitats are unique for Central Europe, thus representing an important target of nature protection within the National Park.

Two typical saline soil types have been described:

* **Solontschak soils** (white alkali soils) are characterized by high salinity in the uppermost soil layers; the „salt accumulation horizon“ reaches the surface of the soil profile. Towards lower soil horizons, the salt content drops strongly.

* **Solonetz soils** (black alkali soils) on the other side, are characterized by originally salt free sediments (sand or clay) of varying thickness covering the „salt accumulation horizon“. Therefore, salinity rises sharply with increasing soil depth. Due to a denser vegetation cover in comparison with Solontschak soils (resulting in a higher humus content in the uppermost soil layers), the color is much darker then in the „white alkali soils“.
However, the superficially deposited sediments are strongly influenced by the subjacent salt horizon, because fluctuations of the ground water table implicate gradual ion exchange processes resulting finally in very high sodium charges of the clay-humus-complexes.

The smaller the particle size of sediments is (clay, silt) the more and broader cracks are formed during exsiccation by spring and summer drought: the volume of clay varies strongly with the water content, esp. when sodium is present in high amounts.



Distribution of water soluble salts,
pH and conductivity (L) in:

* Solonetz (above)

* Solontschak (below)

Depth of the soil profile in both cases: 1 meter

Aus **Ghobadian** 1966 (Diss Univ. Bodenkultur)

Both soil types are characterized by special plant communities

Around soda ponds where Solontschak soils dominate, the **vegetation** forms often **concentric zones** as the result of declining soil salt gradients towards the fringe of the pond.

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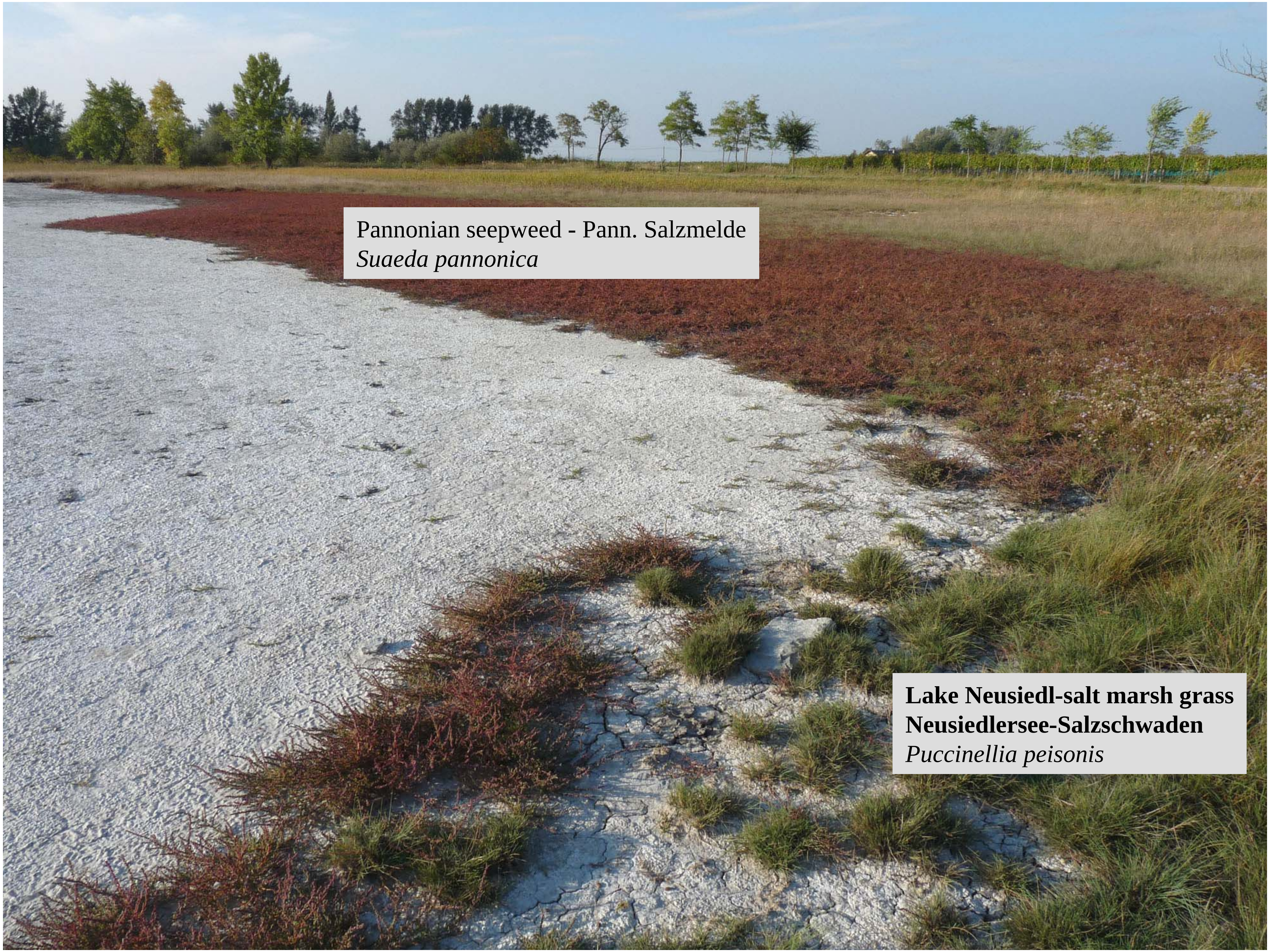
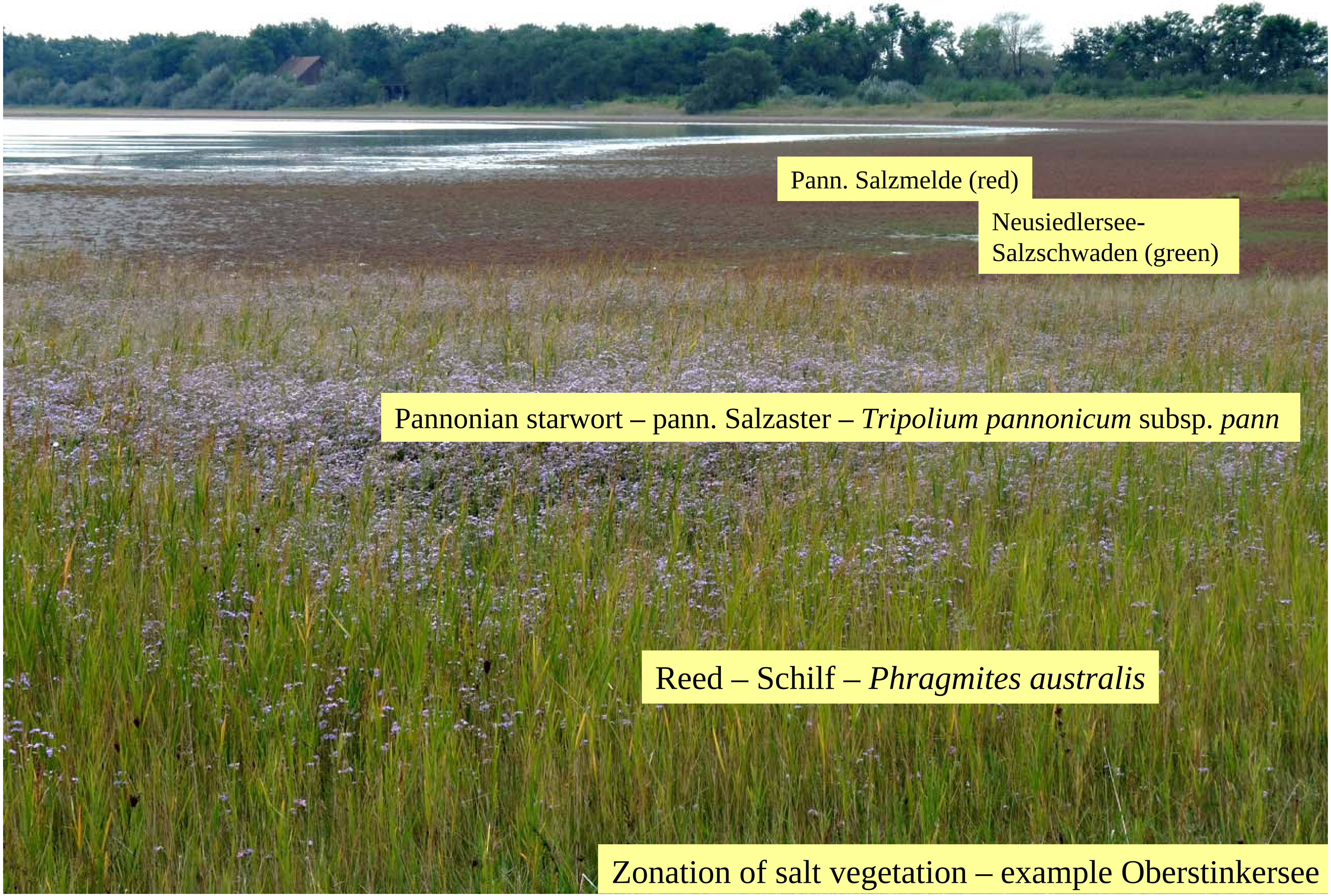
The innermost zones with the highest soil salinity are covered with the „Niedriges Dorngras“, *Crypsis aculeata*, a C-4 species

Members of the goosefoot-family (Gänsefußgewächse) - Chenopodiaceae (*Suaeda pannonica, Chenopodium crassifolium, Ch. glaucum, Atriplex prostrata*, rarely also *Salicornia prostrata*) dominate the strand zones with high soil salinity.


Pannonian seepweed - Pann. Salzmelde
Suaeda pannonica
Lake Neusiedl-salt marsh grass
Neusiedlersee-Salzschwaden
Puccinellia peisonis


Pann. Salzmelde (red)
Neusiedlersee-
Salzschwaden (green)
Pannonian starwort – pann. Salzaster – *Tripolium pannonicum* subsp. *pann*
Reed – Schilf – *Phragmites australis*
Zonation of salt vegetation – example Oberstinkersee

Barren spots with extremely high soil salinity, allowing only a few very salt tolerant species to cope with, are called

„Blindzick-Stellen“ - „Blindzick spots“

One can find these eye-catching spots often in connection with the saline pond, but also scattered everewhere throughout the whole area, **whenever „salt accumulation horizons“ appear on the soil surface**.

The hungarian expression „zsik“means „saline mud“.


Pann. Salzmelde (red)
Pann. Salzaster (violet)
NSSee-Salzschwaden

„Blindzick-spot“ with Salzkresse – salt pepperwort– *Lepidium cartilagineum*

Salzkresse – salt pepperwort is the most prominent halophytic species on Solontschak soils

Spargelklee
Lotus maritimus Wetland with moderate salinity

Moderate saline wetland with saltmarsh arrow grass (Meerstrandsdreizack) - ***Triglochin maritimum***)

The vegetation on Solonetz soils, occuring mostly in the eastern part of the „Seewinkel“ differs markedly from Solontschak vegetation. „Blindzick spots“ are rare, the vegetation cover is denser, because of general lower salt content of uppermost soil horizons.

„Salz-Wermut“ – salt wormwood (salt absinth) – *Artemisia santonicum* dominates, constituting the „Wermut-Salzsteppe“ – „wormwood salt steppe“ as a special vegetation type. Some very rare species (*Camphorosma annua*, *Pholiurus pannonicus*, *Plantago tenuiflora* and others) occur in moist ranges.

„Wermut-Salzsteppe“ – „wormwood salt steppe“ with salt wormwood – **Salz-Wermut** (*Artemisia santonicum*)

The halophytic flora in the „Seewinkel" - all together about 50 species (!) - represents **the most divers halophilous plant communities in Europe.** The reason for this richness is, that „**Westeners**", originating from the coastal zones of the atlantic ocean, are mixed up with „**Easteners**", coming from continental eastern Europe and western Asia. Additionally, due to geographical isolation, some taxa developed subspecies (Salzaster – salt starwort: *Aster tripolium* subsp. *pannonicum*) or even endemic forms: Lake Neusiedl-Salzschwaden: *Puccinellia peisonis*, according to the latin name „Lacus peiso" for the Lake Neusiedl.

Moreover, the chemical diversity of our saline soils, with a mixture of

Soda ($NaHCO_3$/Na_2CO_3)
common salt (NaCl)
epsom salt ($MgSO_4$) and
glauber's salt (Na_2SO_4)

may also contribute to the species richness.

Adaptation of plant on saline soils

* Uptake of a certain amount of salt is necessary for an **adequate osmotic adaptation**, which enable the plant to take up water from a medium with low water potential.

Quantity and quality of salt accumulation may differ markedly between plant species and families. **Dicotyle families take up substantially more salt ions than Monocots,** which are rather „salt excluders“. For osmotic adaptation, however, Monocots accumulate K besides Cl and synthesize soluble sugars, esp. Sucrose.

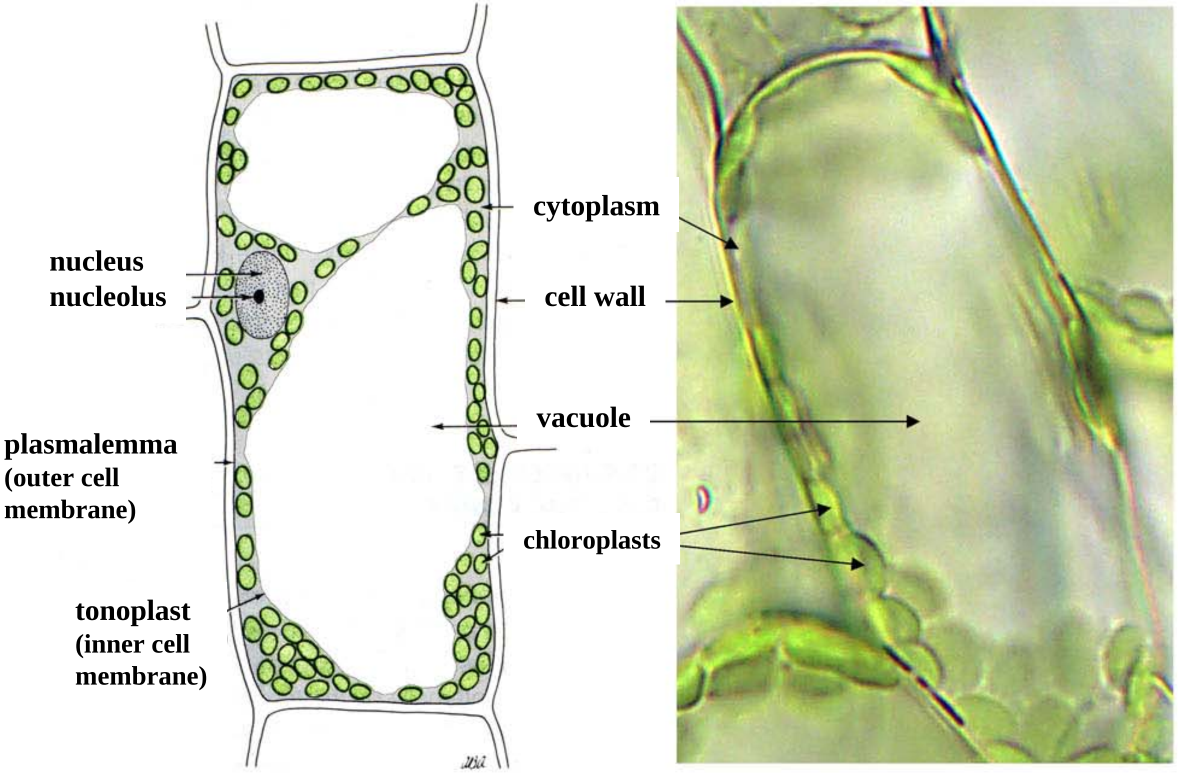
* The most important point is **compartimentation of salt within the leaf cells:**

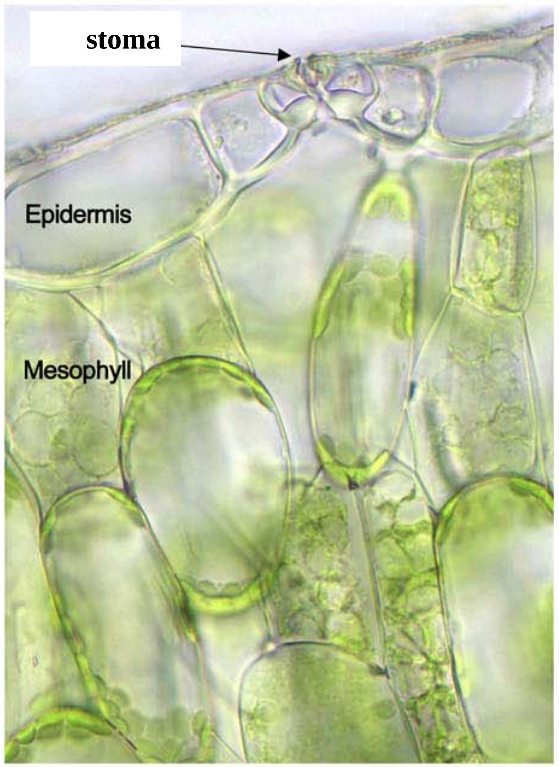
Salt ions are mainly accumulated **within the central vacuole**. On the other side, K which is essential for regulating many metabolic processes is mainly accumulated within the cytoplasm. Additionally, to osmotically compensate for the high vacuolar salt concentration, halophytes have to synthesize some low molecular, **osmotic active organic compounds** which are accumulated **within the cytoplasm**. These compounds are called „**compatible solutes**"

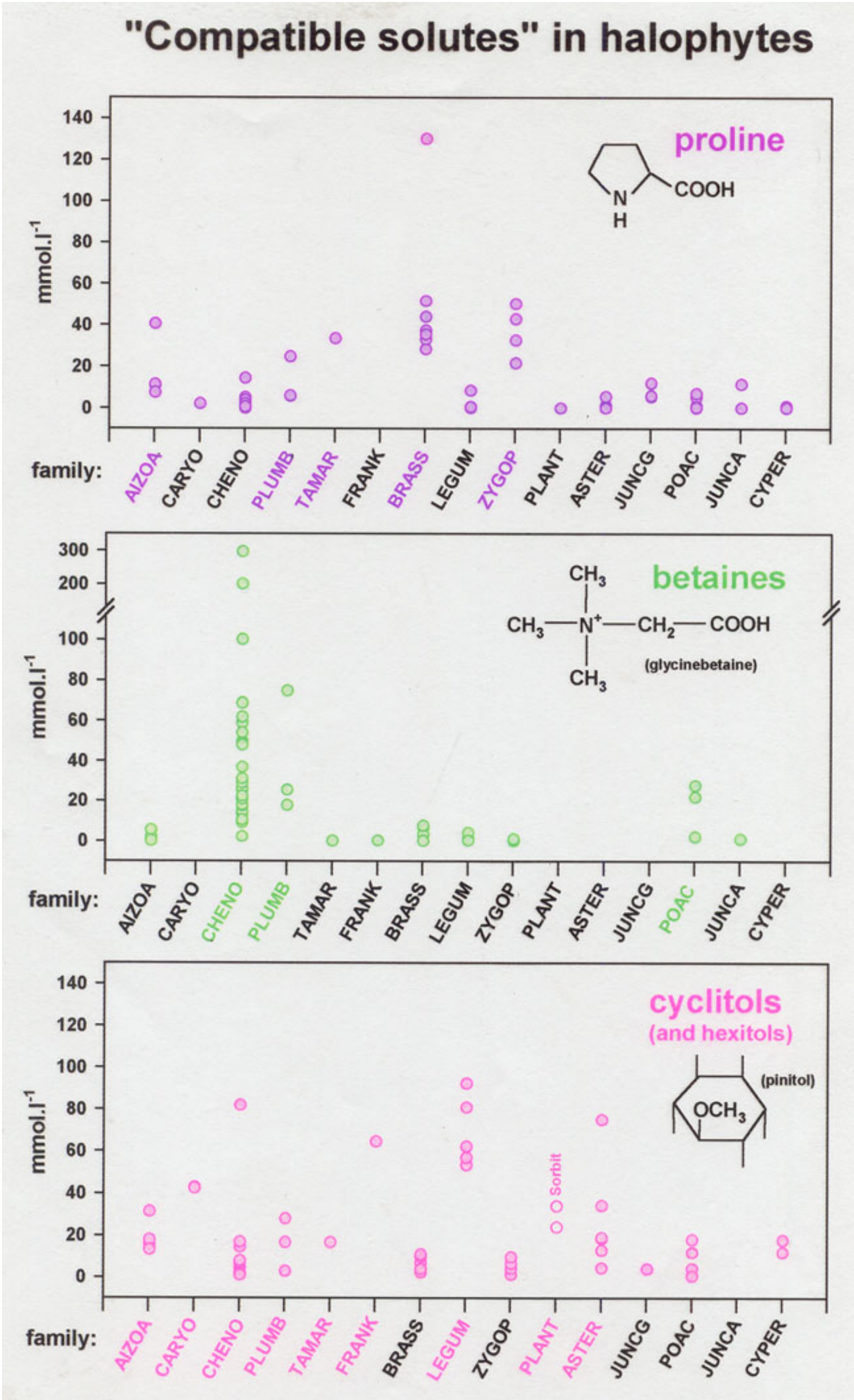
The following slides explain these important facts in more detail:

General scheme of a plant leaf cell (mesophyll cell): As a thin layer, the (living) cytoplasm touches closely the inner surface of the (lifeless) cell wall. The central part of the cell is taken up by the so called „vacuole“, which is an aqueous solution of a variety of substances like inorganic ions (Na, K, Mg, Ca, chloride, sulphate, nitate, phosphate), organic anions (malate, citrate, oxalate, and other organic acids), sugars, free amino acids and a huge amount of so called „secondary metabolites“, like colored, toxic or – generally - „bioactive“ low molecular compounds. The vacuole – like the cell wall – is also a lifeless cell compartment. The processes of plant metabolism goes on exclusively within the thin layer of about 5 % living cytoplasm!

The crucial point for plants living on saline soils is, that elevated concentrations of Na and Cl are generally toxic for all enzymes and all other bio-macromolecules within the cytoplasm. Therefore, the bulk of salt ions, the uptake of which, however, is necessary for an adequate „osmotic adaptation“ to saline soils, must be accumulated within the central vacuole, whereas the cytoplasm is kept nearly salt free. In order to compensate there the lacking osmotic active ions, halophytes have to synthesize some low molecular and osmotic active organic compounds within the cytoplasm. Because these compounds must by harmless for the complex living processes, esp. For the optimal activity of enzymes, they were called „compatible solutes“ (in german: „cytoplasmatische Osmotika“ or „kompatible Verbindungen“).







According to this general family distribution scheme, our most common halophilous species use as „compatible solutes“:

(1) proline: *Triglochin maritimum*, *Lepidium crassifolium*

(2) betaines: all chenopods *(Suaeda*, *Salicornia*, *Chenopodium* sp., *Atriplex prostrata*, *Camphorosma annua)*

(3) cyclitols: *Lotus maritimus*, *Lotus tenuis*, *Spergularia* sp.

(4) hexitol (dulcitol): *Plantago maritima*

Some species uses two or even three compounds in varying amounts:

(5) betaines, proline and/or cyclitols:
Grasses, Cyperaceae, Juncaceae and Asteraceae *(Aster triplolium)*

* Most of the Dicotyle species show the phenomenon of the „**salt succulence**“ („Salz-Sukkulenz“) with progressive leaf ageing. Salt succulence is an universal and basic strategy of halophytes to dilute a surplus of salt ions, which are inevitably taken up along with the transpiration stream.

* The sklerophyllous leves of Monocots can not become succulent. However, due to their leaf growth strategy (embryonal zone on the leaf basis) they are able to replace the older (= upper) leaf zones continuously. Therefore, in an analogous meaning of „dilution“, Monocots „dilute“ the salt in their leaves (the level of which is only moderate - they are relative „salt excluders“, see above!), by growth.

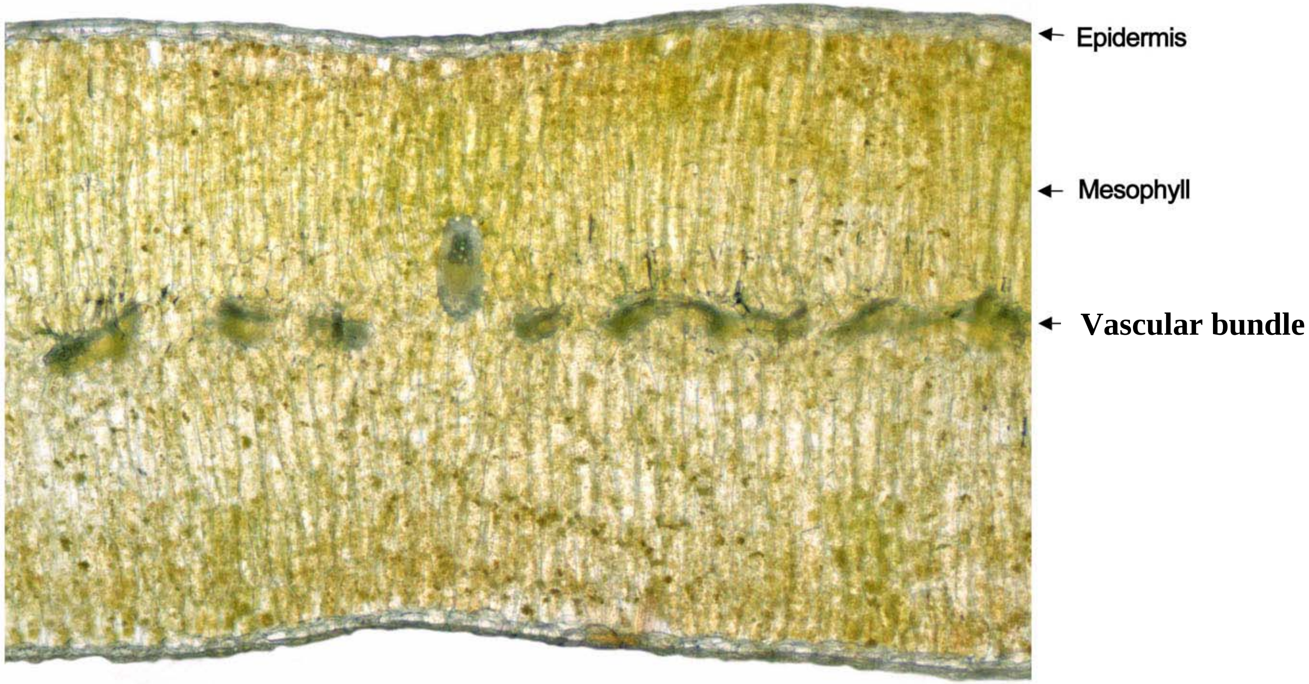
Salzkresse
salt pepperwort
Lepidium cartilagineum

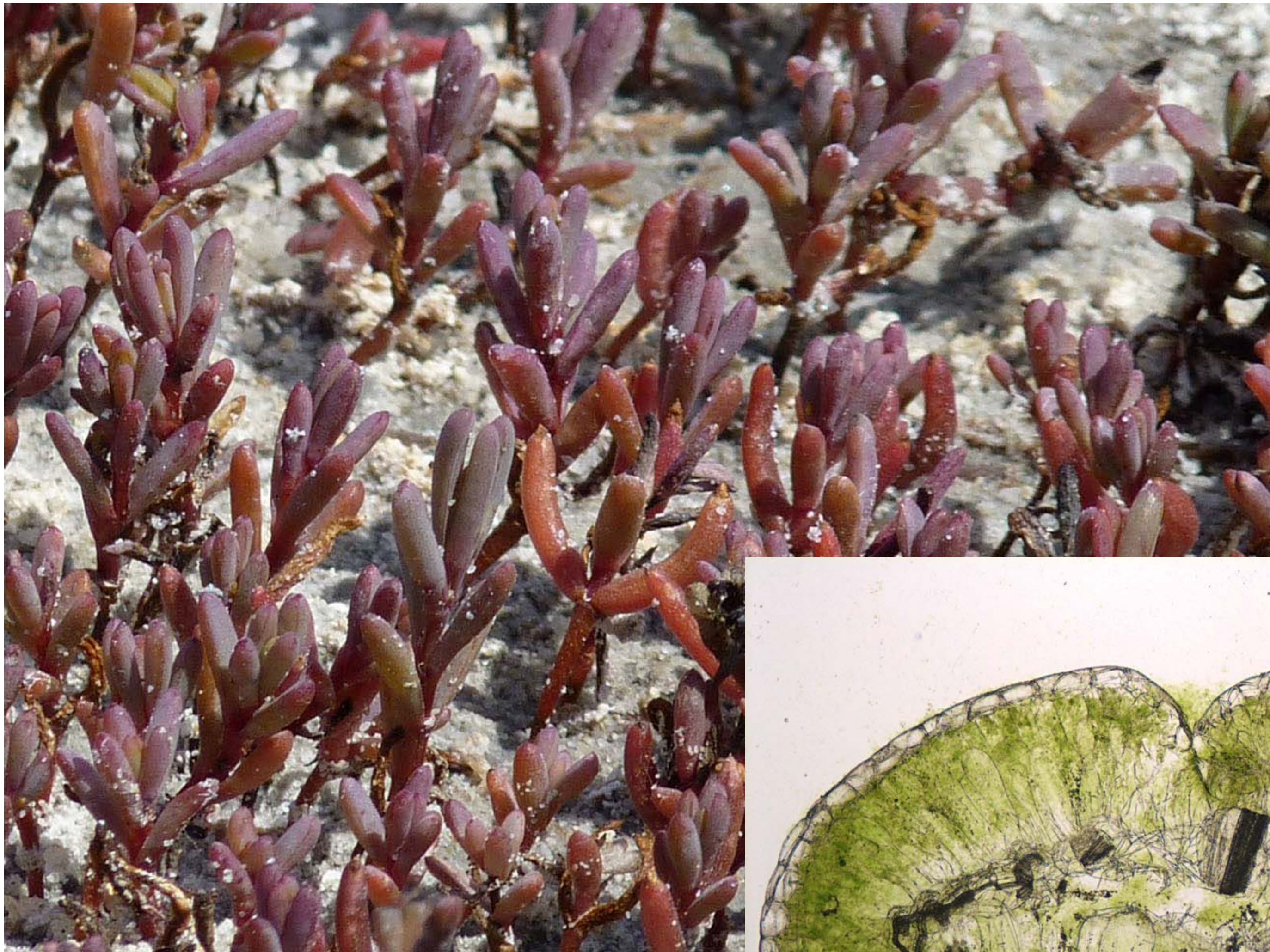
The degree of **succulence** - i.e. the ratio between water content (g) and leaf surface (cm^2) - rises continuousely with leaf ageing due to cell enlargement resulting in an increase in leaf thickness. By this **„dilution effect“**, the concentration of salt ions, which are continuousely transported from the soil solution to the leaves via the transpiration stream, can kept almost constant.

Thus, a toxic salt excess within leaves can be avoided, and the leaf‘s life span is prolongated.

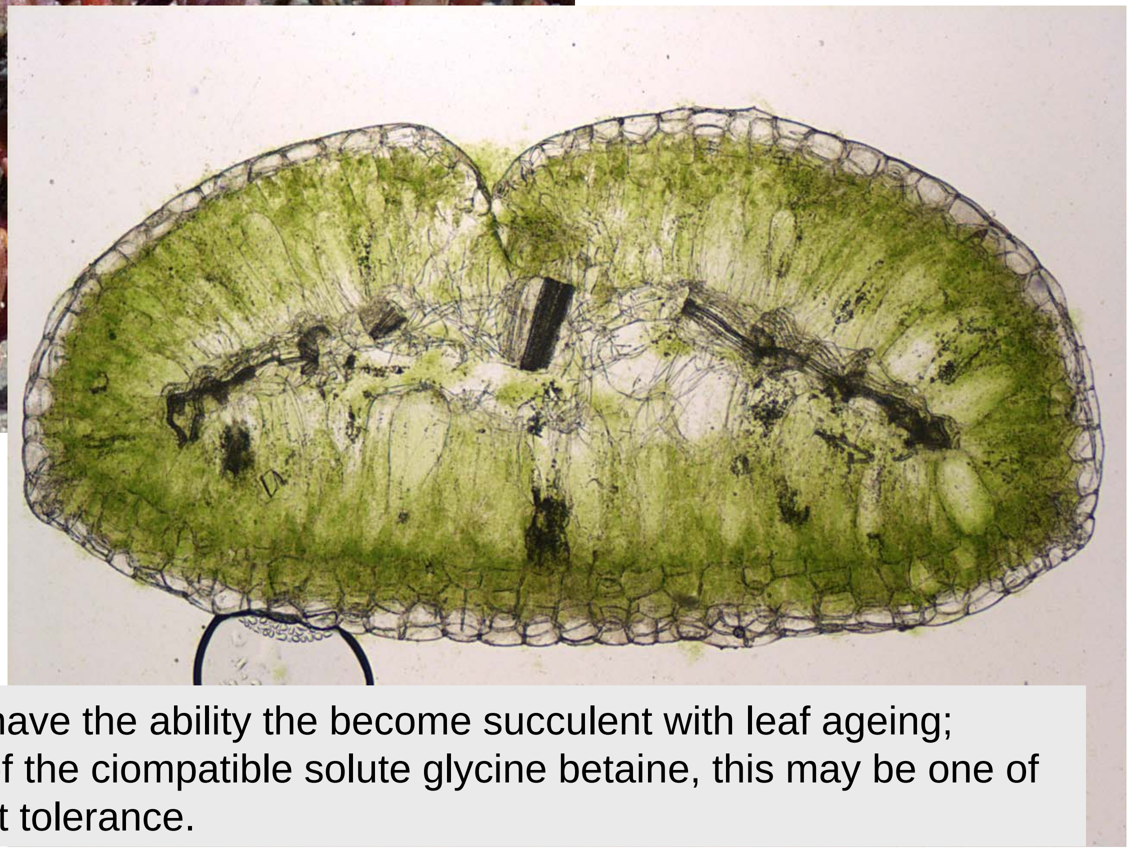
young leaf

old leaf





Suaeda pannonica
Salzmelde

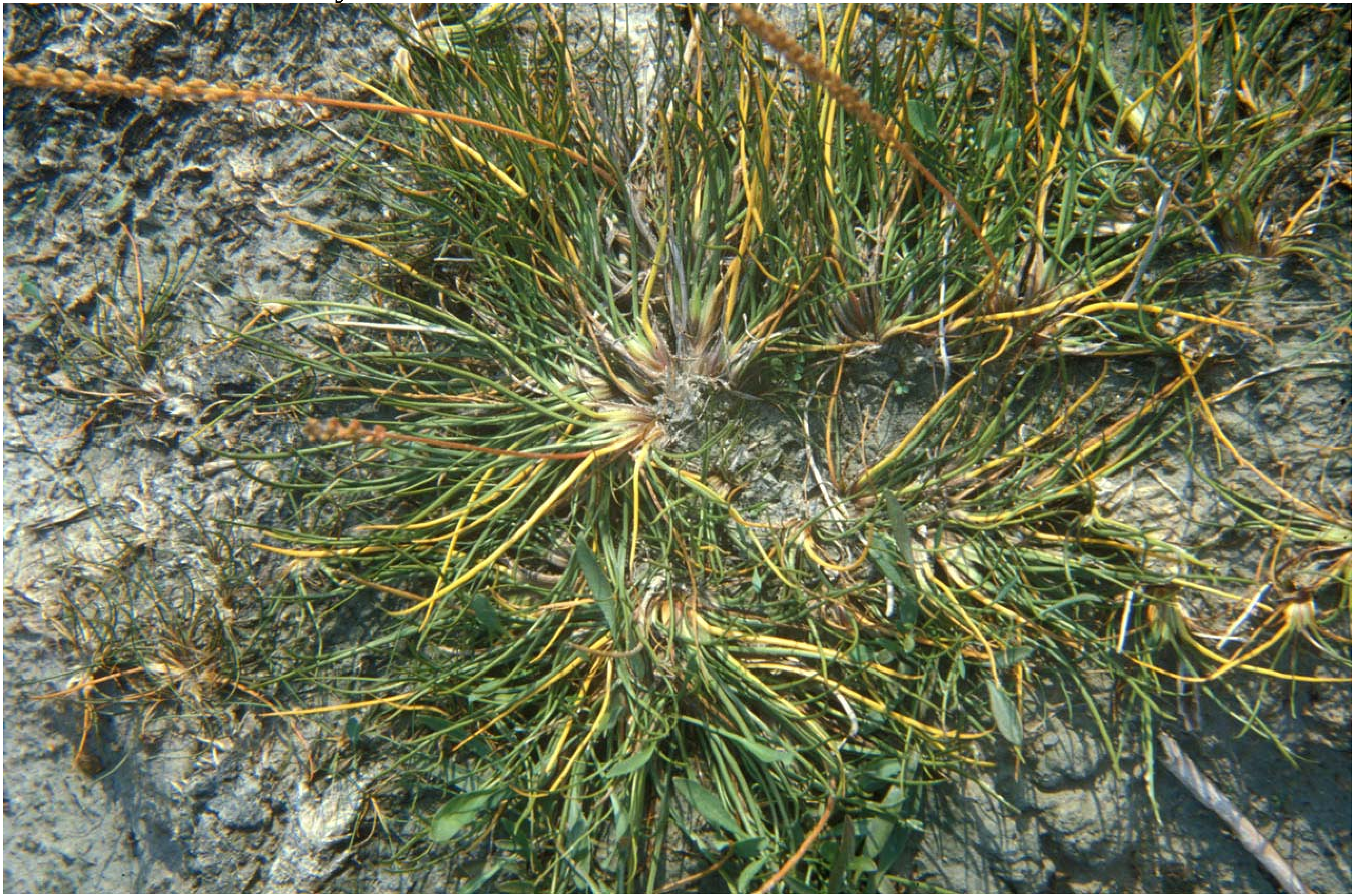


esp. the leaves of the Chenopodiaceae have the ability the become succulent with leaf ageing; besides of the occurence of high levels of the ciompatible solute glycine betaine, this may be one of the reasons for their exceptional high salt tolerance.

* Species with basal „**rosettes**“ – i.e. a basal „wreath“ („Kranz“) of many leaves, inserted on a very compressed stem - **continuously shed there old leaves** with salt ion excess **replacing them by new young and still salt-poor leaves**. Thus, the individual as a whole can keep its absolute salt load almost constant.

Examples are sea plantain (Meerstrands-Wegerich) - ***Plantago maritima*** and saltmarsh arrow grass (Meerstrandsdreizack) - ***Triglochin maritimum***)

Triglochin maritimum as example for a „rosette plant“; the old, yellow leaves with high salt burden are clearly to see



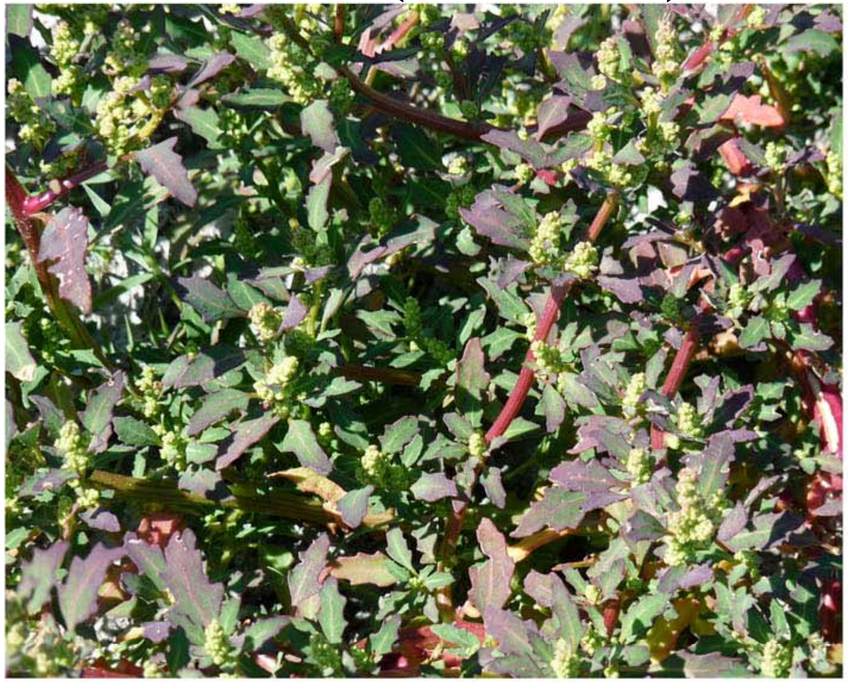
* ***Atriplex prostrata*** („triangle orache“ – Spießmelde) and goosefoot-species: ***Chenopodium glaucum*** („glaucous goosefoot“ – meergrüner Gänsefuß) und ***Ch. crassifolium*** („red goosefoot“ – Dickblatt-G.) can get rid of salt excess by so called „bladder hairs“ – „Blasenhaare“

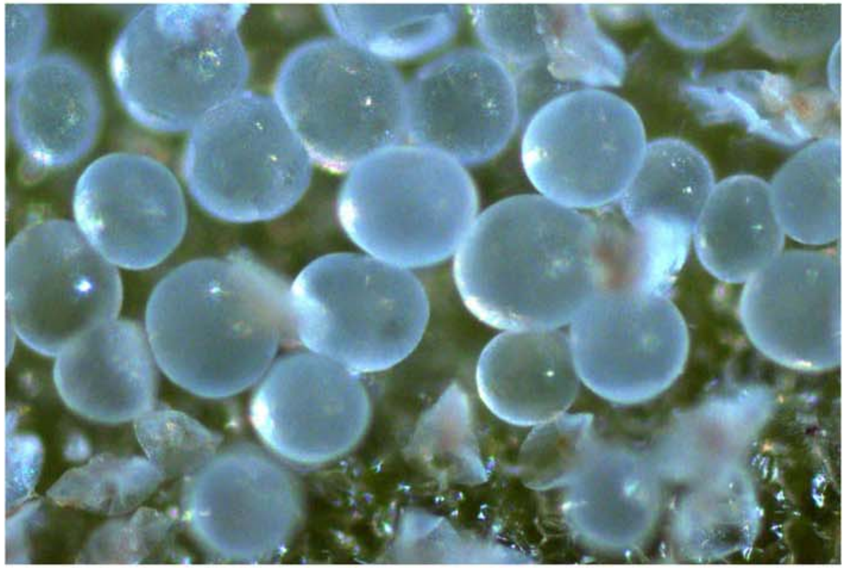
The Epidermis of the lower surface of young leaves develops hairs with a few small cells serving as peduncle for a huge spherical cell. This structure is referred to as **„bladder hair“ („Blasenhaar“).** Via the peduncle cells, salt ions can be transported from the leaf mesophyll towards the huge vacuole of the bladder cell, where they are concentrated up to concentrations of 2 to 3 Mol per litre! When the ion concentrations within the bladder vacuole reaches extreme dimensions, the bladder hair dies and collapses, the content dessicates, and the remaining salt crystals are either washed away by rain or blown away by wind.

By these „bladder hairs“, **serving de facto as salt glands**, the mesophyll cells of the young leaves are discharged from excess salt ions.

Die following slides show this mechanism with *Chenopodium glaucum*

The bladder hairs (Blasenhaare) form a whitish layer on the lower leaf surface





Bladder hairs („Blasenhaare“) of *Chenopodium glaucum*

Bladder hairs (Blasenhaare) of *Chenopodium glaucum* (low magnification). Some of the hairs are already collapsed.

the salt succulence, visible by the enlarged mesophyll cell, is a second anatomical adaptation mechanisms to salinity.

* *Crypsis aculeata* (niedriges Dorngras; left) and *Camphorosma annua* (Kampferkraut, right) are halophytic species showing the so called „C 4 metabolism“. This special photosynthetic mechanism, realized in many plant families from dry habitats, allows the plants to have a very economic water turn over, thereby limiting the passive salt intake along with the transpiration stream.