*Bol. S.E.A.*, nº **24** 1998 (1999): 101-104.



**McM**

# Halophytic and gypsophytic vegetation of the Ebro-Basin at Los Monegros

Prof. Siegmar-W. Breckle

Department of Ecology,
Faculty of Biology, University of Bielefeld
Psotal Box 100131, D-33501 Bielefeld, Germany
e-mail: sbreckle@biologie.uni-bielefeld.de
Internet: www.uni-bielefeld.de/biologie/Oekologie/index

**Abstract**: The natural vegetation cover of the arid Ebro-Basin with some winter-frost is not a steppe or a dwarfshrub semi-desert but an open woodland with single low trees of *Pinus halepensis* and *Juniperus thurifera* (Walter 1973). The undergrowth is also relative frostresistant with *Rosmarinus officinalis, Brachypodium ramosum, Stipa lagascae* etc. The formerly wide-spread *Lygeum spartum*-community on colluvial soils with gypsum is mostly replaced by wheat-fields today as well as the halopyhtic vegetation in the smaller or larger endorrheic hollows. The latter both vegetation types are azonal vegetation types, which form a unique pattern in the area. On the gypsum outcrops grow many interesting species of endemic gypsophytes. The halophytes of the rather saline small basins are not only characterized by their salt-resistance (to NaCl), they have to withstand traces of other salts, too, as e.g. relatively high Mg-concentrations (Breckle 1975). The ionic pattern of halophyte types was checked from various localities. The whole gypsum and saline patterned hilly area around the Los Monegros region is very unique and has to be protected with highest priority.

## Steppe, semidesert or open woodland?

Within Europe parts of the Hungarian basin (Pannonia) and South-Eastern Spain are dry regions, where trees suffer and thus woodlands are not the natural vegetation. Scientific discussions and interest on the Los Monegros area are very old. Willkomm (1896) termed the mentioned regions as steppes. For the Ebro-basin there were similar discussions from phytosociological and ecological viewpoints (Walter 1973). Since then often it was speculated what the natural vegetation of those regions could be. Whereas the southeastern area between Alicante and Almeria in some parts is almost dry like a desert (110 mm of rain per year, Cabo de Gata, Freitag 1971), the Hungarian basin receives more than 300mm and is climatically rather continental with cold winters and hot summers. In comparison with the other mediterranean regions also the Ebro basin is rather continental with frosts in winter, receiving between 300 and 400mm rain mainly in spring and fall.

It has to be kept in mind that the geological history of the area is also unique. The miocenic gypsum layers are very thick, they contain thinner layers of salty marls and clay. This gypsum plateau nowadays is cut by strong erosion in many remnant hills, but close to the road Bujaraloz - Pina de Ebro, parts of the plateau are visible. All the small valleys are dry, even episodic creeks are missing. The hydrographic system is partly independent from the river Ebro; this is a clear indication of an arid area with small endorheic hollows. This is probably enhanced by karst phenomena in the gypsum layers.

On the tertiary limestone of the Sierra Alcubierra open *Pinus halepensis*-woodlands with shrubby *Quercus coccifera* and dwarfy *Arctostaphylos uva-ursi* are present (Braun-Blanquet & Bolos 1957). This is typical xero-mediteranean vegetation. In small remnants between the wheatfields of the gypsum area there are groups of *Pinus halepensis*, but also *Juniperus thurifera*, in the undergrowth many *Rosmarinus officinalis*, also *Brachypodium ramosum, Agropyrum cristatum*, less *Stipa lagascae*. All around on open spaces the mass of annuals in late spring is conspicuous (Eremopyreto-Lygeetum according to Braun-Blanquet & Bolos).

The typical gypsophytes on open gypsum hills and crests are *Ononis tridentata, Helianthemum squamatum, Herniaria fruticosa, Gypsophila hispanica, Lepidium subulatum, Reseda stricta, Campanula fastigiata* and some others (see also Jäger 1971).

In the lowest parts and clayey basins the catena ends with halophytes, sometimes surrounded by *Lygeum spartum* (Lygeeto-Stipetum lagascae according to Braun-Blanquet & Bolos). It must be mentioned, that here the frost-sensitive typical mediterranean species are lacking (e.g. *Pistacia lentiscus, Phillyrea angustifolia, Rhmanus alaternus, Globularia alyppum*, even *Quercus coccifera and Juniperus phoenicea*, which are not present in the lowest parts).

A few central-asiatic floristic elements, like *Peganum harmala, Salsola vermicularis* and *Artemisia herba-alba* are common along field-margins and as weeds on ruderal places (Salsolo-Peganetum according to Braun-Blanquet & Bolos). Already Willkomm (1896) suggested, that they probably were introduced by the Arabs, and thus are alien plant species.

## Halophytes

The lowest parts in the Los Monegros area, but not connected with the Ebro riverine margins, which is separated by a distinct terrace, halophytic vegetation is pronounced. The original unique vegetation of many of this hollows is destroyed, partly salt was used and collected (La Playa).

**Table 1**

**Ion content in soil from Los Monegros (Breckle 1975). SC = salt crust; Locality I - IV indicate decreasing salinity along a catena (ions as % of dry matter from hot water extracts from soil samples 5 - 25cm; $CaCO_3$: % of total dry matter)**

| | $CaCO_3$ | Na | K | Mg | Ca | Cl | $SO_4$ |
|---|---|---|---|---|---|---|---|
| SC | 0.2 | 32.2 | 0.03 | 1.0 | 0.8 | 60.0 | 1.8 |
| I | 17.9 | 0.75 | 0.10 | 0.15 | 0.06 | 1.6 | 1.05 |
| II | 49.5 | 0.27 | 0.03 | 0.08 | 0.01 | 0.38 | 0.75 |
| III | 40.0 | 0.19 | 0.03 | 0.05 | 0.037 | 0.33 | 1.18 |
| IV | 53.5 | 0.001 | 0.005 | 0.005 | 0.003 | 0.10 | 0.23 |

**Table 2**

**Ion content in plants (leaves or green assimilating organs) from Los Monegros (Breckle 1975). Locality I - IV indicate decreasing salinity along a catena (si: soluble ions as m-equ. per water content of plant tissue from hot water extracts; ii: total content from Hcl-extracts)**

| Species | | Na | K | Ca/si | Ca/ii | Mg | Cl | SO4 | NO3 | Oxalate |
|---|---|---|---|---|---|---|---|---|---|---|
| *Arthrocnemum perenne* | I | 1310 | 185 | 25 | 25 | 210 | 770 | 255 | 8 | 140 |
| *Suaeda brevifolia* | I | 710 | 145 | 15 | 20 | 120 | 320 | 74 | 10 | 200 |
| *Lygeum spartum* | I | 75 | 150 | 2 | 2 | 95 | 240 | 160 | 3 | 2 |
| *Limonium aragonense* | I | 120 | 80 | 7 | 20 | 220 | 190 | 240 | 0 | 30 |
| *Suaeda brevifolia* | II | 620 | 120 | 10 | 15 | 115 | 220 | 70 | 10 | 185 |
| *Arthrocnemum peren.* | III | 1130 | 70 | 23 | 22 | 90 | 600 | 220 | 0,5 | 10 |
| *Suaeda brevifolia* | III | 530 | 100 | 10 | 10 | 80 | 150 | 65 | 6 | 180 |
| *Camphorosma monsp.* | III | 390 | 145 | 10 | 110 | 170 | 390 | 125 | 0,7 | 130 |
| *Eurotia ceratoides* | IV | 17 | 70 | 15 | 30 | 40 | 75 | 250 | 2 | 20 |
| *Artemisia herba-alba* | IV | 25 | 155 | 13 | 55 | 100 | 420 | 170 | 1 | 5 |
| *Rosmarinus officinalis* | IV | 35 | 185 | 17 | 30 | 180 | 115 | 170 | 4 | 5 |

Gypsum blocs from fields were deposited in the hollows. Only some examples of small patches resembling original vegetation have remained.

Analysis of salinity and of ion pattern in some halophytes revealed a wide spectrum of halophyte types (Breckle 1975). Examples of some analytical data are given in table 1, 2 and 3.

The zone richest in salt is characterized by thinner or thicker salt crusts. Patches of *Arthrocnemum* hummocks occur and indicate high salinity. The original zonation of saline soils and halophyte vegetation is only seen in scarce remnants. But even here some hummocks of *Lygeum* occur, too, partly on elevated micro-sites. The alkalinity may play a distinct role, since the pH is 8,7 - 9,0. But the effects on plant roots is not clear. Salinity often plays a desastrous role in agriculture of arid zones (Breckle 1989) and is still one of the biggest problems of mankind.

Preliminary data on ion content of plants are given in Table 2 and 3 from some localities close to Los Monegros, mainly from the salinity catena from the La Playa area. We do not know from more recent analytical data and more other comparable localities of the Los Monegros area, which would give a basis for comparisons along the time-axis. They are strongly needed to show a basis for sustainable nature conservation management, together with inventories of diversity of all main organism groups, but also vegetation and soil types, soil chemistry etc.

A rather wide amplitude is exhibited by *Suaeda brevifolia*. This species occurs on rather different stands. Most of the chenopods indicate their typical halophyte character by accumulation of Na and Cl in cell sap. *Eurotia* (now *Ceratoides*), however is an exception, as shown also from Utah (Moore *et al.* 1972, Breckle 1976) or from Central Asia (Mirazai & Breckle 1978, Breckle 1983, 1986).

**Table 3**

**Ion content in plants (leaves or green assimilating organs) from Los Monegros (Walter 1973). Locality A: *Lygeum-Juniperus*-Locality on gypsum with traces of salts; Locality B: Field-margin with weeds on gypsum soil; (soluble ions as m-equ. per water content of plant tissue from hot water extracts)**

| Species | | Na | K | Cl | SO4 |
|---|---|---|---|---|---|
| *Frankenia pulverulenta* | A | 725 | 105 | 750 | 125 |
| *Lygeum spartum* | A | 12 | 405 | 315 | 62 |
| *Juniperus thurifera* | A | 13 | 195 | 230 | 9 |
| *Gypsophila hispanica* | A | 6 | 90 | 55 | 118 |
| Soil (%) | A | 0,8% | 0,06% | 0,27% | 13,8% |
| *Peganum harmala* | B | 460 | 150 | 150 | 42 |
| *Salsola vermicularis* | B | 12 | 725 | 180 | 90 |
| *Salsola iberica (§ Kali)* | B | 6 | 360 | 55 | 8 |
| *Suaeda brevifolia* | B | 745 | 115 | 270 | 20 |
| *Atriplex halimus* | B | 790 | 275 | 520 | 23 |
| Soil (%) | B | 0,15% | 0,09% | 0,25% | 21,5% |

Very interesting is the ion pattern in *Artemisia herba-alba* (Table 2). It is known, that this species (aggregate) is rather divers in ecotypes. The ionic pattern from the *Artemisia* at Los Monegros indicate a rather halophytic character with a high Cl-affinity. The same is known from *Salsola kali* where several subspecies or ecotypes are known (Reimann & Breckle 1995) mostly with a very prominent potassiophyly (Table 3).

The grasses (e.g. *Lygeum*) exhibit their typical behaviour of a very efficient uptake mechanisms of nutrients, which results in a low accumulation of ions except in the recreting species as in *Aeluropus*. In other regions the salt-recreting species are a very prominent group of halophytes, with efficient physiologically active salt-glands, or with huge bladder cells (as in *Atriplex*), where the stalk cell has a gland-like function (Waisel 1972, Breckle 1976, 1992, Freitas & Breckle 1994).

It has to be taken into account, that all the analyses with the results given in Table 1 and 2 had been made in march, where during the rainy season the lowest (!) salinity is to be expected. Later in the year by capillary upwards movement the salinity increases tremendously, and thus the ephemerals, which were not treated here, cease their short life-cycle (Breckle 1995), whereas the perennials have to adapt themselves on the rising salinities by deep-rooting, by salt-excretion, by shedding leaves etc. (Breckle 1995).

These different adaptations exhibit different competitive abilities. Under natural conditions a typical sequence of halophyte types within a salt-gradient, a catena develops. This sequence could be observed in many regions (Breckle 1986). It is developped also in parts of the Los Monegros salines. Additionally there we have an inland saline which in chemical respect is differeing from marine saline and thus is more unique, by its higher sulphate content and contribution of Mg and Ca to salinity, adjacent to the gypsocolous ridges.

The unique halophytic (and also gypsophytic) ecosystems of Los Monegros have to be studied in detail furtheron, they are a special wealth for science and thus for mankind.

## Conservation

The vegetation of the Los Monegros area also was treated as an excellent example to demonstrate the various adaptations of plant types and lifeforms as strategies to survive harsh conditions (Pedrocchi 1988) of various kinds. As mentioned above, also adaptations to withstand salinity (Breckle 1990, 1992, 1995, 1999) can be studied in that regions in an excellent way. It is thus selfevident, that this area has to be conserved as good as possible, as Dominguez et al. (1996, 1999) had stressed. It is not only an area of unique vegetation with special ecotypes and endemics (Franco Múgica 1994, Casas et al. 1992) with a very special diversity of flora of halophytes and gypsophytes ($\alpha$-diversity) and vegetation (ß-diversity), it is an area with a unique geological history and hence, a unique ecosystems pattern ($\tau$-diversity) with very special ecological mainly edaphical conditions. In addition, Los Monegros has a very special biogeographical and chorological value. Similar but different vegetation types only occur in parts of Eastern Austria and Hungary, in the Ukraine and Central Asia.

## Literature


BRAUN-BLANQUET, J. & BOLOS, O.DE 1957 Les groupements végétaux du basin de l'Ebre et leur dynamisme. *Ann. Estac. Exper. Aula Dei* 5: 1-266

BRECKLE, S.-W. 1975 Ionengehalte halophiler Pflanzen Spaniens.- *Decheniana/Bonn* 127: 221-228

BRECKLE, S.-W. 1976: Zur Ökologie und den Mineralstoffverhältnissen absalzender und nicht absalzender Xerohalophyten (unter besonderer Berücksichtigung von Untersuchungen an *Atriplex confertifolia* und *Ceratoides lanata* in Utah/USA).- Diss.Bot. 35: 169pp.

BRECKLE, S.-W. 1983: Temperate Deserts and Semideserts of Afghanistan and Iran.- in WEST, N. E.(ed.): *Temperate Deserts and Semideserts.- Ecosystems of the World* (ed.: GOODALL,D.W.), vol.5, 271-319. Elsevier/Amsterdam

BRECKLE, S.-W. 1986: Studies on halophytes from Iran and Afghanistan. II. Ecology of halophytes along salt-gradients.- *Proceedings Roy.Bot.Soc.Edinb.*: 89B: 203-215

BRECKLE, S.-W. 1989: Role of salinity and alkalinity in the pollution of developed and developing countries.-*Internat. Symposium on the effect of pollutants to plants in developed and developing countries in Izmir/Turkey* 22.-28.8.1988; ed. by M.A.ÖZTÜRK: 389-409

BRECKLE, S.-W. 1990: Salinity tolerance of different halophyte types.- in: Bassam N.EL et al. (Eds.) *Genetic aspects of plant mineral nutrition.- Plant Soil* 148: 167-175

BRECKLE, S.-W. 1992: Salinity-stress and salt-recretion in plants.- *Bielefelder Ökologische Beiträge* (BÖB), Bd.6: 39-52

BRECKLE, S.-W. 1995: How do plants cope with salinity? - in KHAN, M. A. & UNGAR, I. A. (eds.): *Biology of salt tolerant plants (Proceedings of the Internat. Symposium) Dept. of Botany*, Univ. of Karachi/Pakistan, p. 199-221

BRECKLE, S.-W. 1999: Salinity, halophytes and salt affected natural ecosystems.- in: LÄUCHLI, A. & LÜTTGE, U. (eds.): *Salinity: Environment - Plants - Molecules.*- Kluwer Acad.Publ./ Dordrecht (in press)

CASAS, C., ROS, R.M., BRUGÚES M. & CROS R. M. 1992 Endangered bryophytes of the Iberian Peninsula: Los Monegros.- *Biol. Conservation* 59: 221-222

DOMINGUEZ, F., GALICIA, D., MORENO, L., MORENO, J. C. & SAINZ, H. 1996 Threatened plants in Peninsular and Balearic Spain: a report based on the EU habitats directive.- *Biol. Conservation* 76: 123-133

DOMINGUEZ, F., FRANCO, F., MOREON, J.C., ORUETA, D. & SAINZ, H. 1999 La conservación de la flora amenazada de Aragón: una estrategia en marcha.- www.quercus.es/ RedQuercus/Articulos/flora.htm; 7p.

FRANCO MÚGICA, F. 1994 El crujiente aragonés, um paleoendemismo estepario.- *Quercus* 104: 20-21

FREITAG, H. 1971 Die natürliche Vegetaion des südostspanischen Trockengebiets. *Bot. Jahrb.* 91: 147-308

FREITAS, H. & BRECKLE, S.-W. 1994 Importance of bladder hairs for seedlings of some *Atriplex* species.- Mésogée 53: 47-54

JÄGER, E.J. 1971 Die pflanzengeographische Stellung der <<Steppen>> der Iberischen Halbinsel.- *Flora* 160: 217-256

MIRAZAI, N.A., BRECKLE, S.-W. 1978: Untersuchungen an afghanischen Halophyten. I. Salzverhältnisse in Chenopodiaceen Nord-Afghanistans.- *Bot.Jahrb.System.* 99: 565-578

MOORE, R.T., BRECKLE, S.-W. & CALDWELL, M.M. 1972: Mineral ion composition and osmotic relations of *Atriplex confertifolia* and *Eurotia lanata.- Oecologia* 11: 67-78

PEDROCCHI, C. 1988 Las estrategies de supervivencia de las plantas. en PEDROCCHI, C. (ed.) *Ecología de Los Monegros. La paciencia como estrategia de supervivencia.* Centro de Desarollo de Los Monegros, Huesca. members.xoom.com/monegros/estrategias.htm;

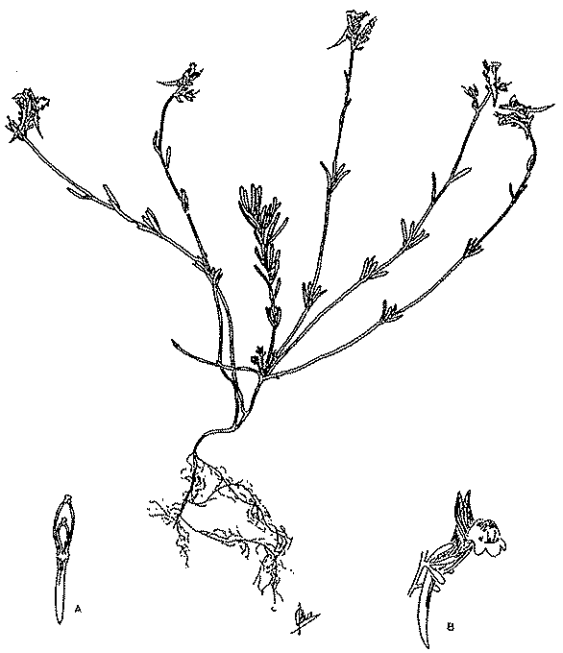
PUERTAS, J.QU. 1965 Nota sobre las lagunas de Bujaraloz-Sastago.- *Geografía/Zaragoza* 12: 30-34

REIMANN, C. & BRECKLE, S.-W. 1995: Salt tolerance and ion relations of *Salsola kali* L.: Difference between ssp. *tragus* (L.) NYMAN and ssp. *ruthenica* (ILJIN) SOO.- *New Phytologist* 130: 37-45

WAISEL, Y. 1972 *Biology of halophytes.*- Acad. Press/New York

WALTER, H. 1973 Ökologische Betrachtungen der Vegetationsverhältnise im Ebrobecken (Nordost-Spanien).- *Acta Bot. Acad. Scient. Hungar./Budapest* 19: 393-402

WILLKOMM, M. 1896 Grundzüge der Pflanzenverbreiutung auf der Iberischen Halbinsel; in: ENGLER & DRUDE: *Die Vegetation der Erde,* Band 1, Leipzig


*Linaria glauca* (L.) Chaz. Ssp. *aragonensis* (Lange) Valdes.
**A**: Estambres. **B**: Detalle de la flor. (Dib. O. Escudero)