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Origin and development of the salt steppes and marshes in SW Slovakia

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Abstract
Pannonic salt steppes, salt marshes and inland salt meadows are included in the list of European priority habitats. These alkali habitats are very rare in Slovakia, they occur mainly in lowland areas of SW and SE Slovakia. We assume the existence of primary and secondary saline habitats in Slovakia but their historical area was different. We tried to reconstruct the origin and development dynamics of salt steppes and salt marshes on the basis of paleopedologic, archeobotanic and palynologic findings, historical papers, maps and geografic names, etnobotanic and agrohistoric data. The paleo-pedological and archeobotanical resources give only limited valuable data. The medieval written works also contain only minimum useful data. The local geographical names identifying saline habitats are known from the 18th and 19th centuries, often originating before hydro-ameliorative interventions into the landscape. Alkali habitats could expand as a consequence of this amelioration and large-scale sheep breeding. The largest area they covered was probably reached in the 19th century. In the 20th century the most alkali habitats were recultivated. Today we can find only small fragments of salt steppes, many of which are protected. The paper is ended by a critical analysis and comparison of knowledge from other regions of the Carpathian Basin.

Összefoglaló: A sziki sztyepek és mocsarak eredete és fejlődéstörténete DNy-Szlovákiában
A pannon szikesek európai szintű védettséget élveznek. Szlovákiában ritkák, utolsó töredékeik az ország délnyugati és délkeleti részén találhatók. Megfigyeléseink szerint elsődleges és másodlagos szikesek egyaránt fennmaradtak, bár kiterjedésük jelentősen változott az idők folyamán. A recens szlovákiai botanikai irodalom, néhány ritka kivételtől eltekintve, csaknem teljesen mellőzi a szikesek fejlődéstörténeti kutatását. A rájuk eső elszórt utalások régi iskolákra támaszkodnak, és nem veszik figyelembe a legújabb magyarországi kutatásokat. A tanulmány kísérletet tesz a sziki sztyepek és mocsarak kialakulásának rekonstrukciójára.

A paleopedológiai és archeobotanikai kutatások kevés értékes adatot tudnak felmutatni. A középkori írásbeliség ugyancsak szegényes értelmezhető információközlésben. A szikesekre utaló helyi földrajzi nevek (pl. sós, szikes) a 18–19. században bukkannak fel, esetenként még a vízrendezések előtt. A legrégebbi beszédes folyónév a Szikince, mely 1523-ban, talán éppen az alsó folyásánál található szikesek nyomán kapta újkori nevét (korábban: Szityince). Az 1663–1664. évi török adóösszeírásokban szereplő „Szíközs Hon, puszta” (hon = dűlő) földrajzi név talán a verebélyi érseki nemesi szék birtokára utal. A legrégebbi komolyabbnak vélhető utalásokat 1734-ből (Tardoskedden „Szeges”) és 1764-ből (Dunamocson „Sósok”) ismerjük, ez utóbbi helyen Bél Mátyás már több mint száz évvel korábban „fehér mezőket” említ. A szikesek kiterjedése a lecsapolások és folyószabályozások során megnőhetett, e kor szytepi belterjes juhtenyésztésére gazdag irodalom utal. A szikes talajok és élőhelyek a 19. században érhették el kiterjedésük maximumát, erre következtethetünk a korabeli földrajzi nevekből és az írott kútfőkből. A népnyelvi „égevényes” v. „ígevínyes” megjelölés is valószínűleg sós talajokra utalt. A felvidéki szikesek a 20. században csaknem teljes egészükben a termőtalajszerző rekultivációknak estek áldozatul. Ma már csak kis töredékeiket találjuk, gyakran erősen degradált állapotban (Mocsonok, Tardoskedd, Nagysurány, Nagykeszi, Csallóközaranyos, Izsa, Búcs, Kőhídgyarmat, Kéménd térségében). Nagy részük törvényi védelmet élvez.

Tanulmányunkat átfogó, kritikai elemzéssel fejeztük be és eredményeinket összevetettük a Kárpát-medence más földrajzi területein szerzett ismeretekkel, tapasztalatokkal.

Introduction

Latterly relatively valuable works have been published about the origin and development of forestless vegetation of Central Europe but they are focused mainly on glycophilous plant communities on loess and other geological bedrocks (e. g. LOŽEK 2004, 2005). In the recent Slovak papers there is still little information about the origin and development of alkali habitats except by SÁDOVSKÝ et al. (2004) who presented historical and actual maps of the occurrence of this type of habitat. They supposed a decrease of area of alkali habitats from ca. 8.300 ha to ca. 500 ha on 20 localities during the last century. At present these habitats are rare and endangered and are more and more often found only in a degraded state. Pannonic salt steppes and salt marshes and inland salt meadows are included in the list of European priority habitats (Nr. 1340 and 1530, ANON. 2003).

The alkali steppe habitat is called „*szik*" (common in Hungarian, originated from the Latin *siccus* = dry, sun-dried?, in Slovak: „*slanisko*" from *slané* = salty, saline) and a forestless steppe area is called „*puszta*". The *alkali vegetation* grows more or less on wet alkali soils, including marshes. Its modified classification has been prepared by MOLNÁR – BORHIDI (2003). There is a close correlation between the soil salinity and alkali grassland vegetation (e. g. TÓTH – RAJKAI 1994), therefore we need a reliable classification of salt-affected soils (review of Hungarian and Central European classiffication systems see at TÓTH – VÁRALLYAI 2002).

It is very difficult to reconstruct the historical development of salt marshes and salt steppes from generally available sources. As given by MICHALKO et al. (1987), in Slovakia it is a hypothetical question whether halophytic phytocoenoses originated as climax associations or developed only after the removal of the native forests. The present geobotanical literature does not doubt the originality of some alkali habitats in Hungary (primary alkali habitats) (SÜMEGI et al. 2000). The saline habitats could enlarge their area after water flows regulation, drainage of marshes and traditional grazing throughout centuries (c.f. VARGA – VARGÁNÉ SIPOS 1999). The newest criticism of published data is given by MOLNÁR (2003) and MOLNÁR – BORHIDI (2003), who point also to some differential signs of primary and secondary alkali meadows by comparing the species composition, vegetation mosaic patterns, soil type and entire landscape contrast. MOLNÁR (1999) considered alkali steppes to be primary only in such areas that were salty in large areas even before hydro-ameliorative regulations and their water balance has not changed significantly after drainage. In 2003 he (and also with BORHIDI) added that the primary alkali vegetation is characterized by contrasted vegetation mosaics, biodiversity, well-developed alkali geomorphology and the lack (or subordination) of floodplain species. He considers only those sziks as secondary which are saline only partially and originated in the course of water flows and also inner waters regulations where the soil was not salty or was salty but only locally. They originated from regularly flooded meadows and marsh meadows. In the last years new works have been published focusing on the development of Pannonian forestless and forest-steppe habitats (e. g. MOLNÁR – KUN 2000, SÜMEGI 2005, SÜMEGI et al. 2006), dynamics and biodiversity of Austrian alkali habitats (OBERLEITNER et al. 2006), soil salinity (e. g. KOVÁCS et al. 2006, TÓTH – SZENDREI 2006) and on hydrology of the Pannonian Basin (e. g. TÓTH 1995, MÁDLNÉ SZŐNYI et al. 2005).

We can not speak about large „szik“ areas in Slovakia, but their location and expansion in the past could be different from the present. Also the research of other grassland communities in the Carpathian Basin has to overcome some uncertainties. The anticipated forest steppe (and steppe?) associations in Central Europe are of double origin: either sub-Mediterranean or continental (c.f. VARGA et al. 2000).

Our aim therefore can not be to answer the most serious questions (where, when and how did the alkali habitats originate?), but we want to focus on the issues of interdisciplinary research methods application in the course of their study.

Material and methods

Within the paper we have carried out a floristic and geobotanical research of the West Slovakia salt marshes and steppes in the years 2000-2006 in the localities of Močenok, Tvrdošovce, Šurany, Veľké Kosihy, Zlatná na Ostrove, Iža, Búč, Kamenný Most, Kamenín. For the interpretation of the phenomena we have used quoted works related to:

- paleopedologic, archeobotanic and palynologic findings
- archival papers, maps and geografic names (toponyms)
- etnobotanic and agrohistoric data
- critical analysis and comparison of knowledge from other regions of the Carpathian Basin

In the paper syntaxonomic names according to VARGA – VARGÁNÉ SIPOS in BORHIDI – SÁNTA (1999) and/or MOLNÁR – BORHIDI (2003) are used, while at certain individual syntaxa their work gives a detailed reasoning why they refuse some names according to MUCINA et al. (1993) or VICHEREK (1973). Our work does not refer only to one type of alkali habitat because isolated halophytic phytocoenoses without any reference to other accompanying associations exist only rarely (or do not exist at all). They emerge like a set (mosaic) of associations with corresponding edge/periphery /margin and neighbouring associations whether forest or meadow with a different degree of salination and different water balance (they are the so called “super-associations” or sigma-communities).

Plant species names were adjusted according to MARHOLD – HINDÁK (1998).

Results

1. Paleopedological and archeobotanical findings

Salty soils belong to the group of semi-terrestrial soils characterized by an increased content of mineral salts solluble in water (solonetz, solontchak). Salinization of soils is a pedogenetic process in areas with a high evaporation or a bad drain on mineralized soils. The soil profile is affected by capillary supported strongly mineralized ground water. It follows very clearly that salty soils in our territory could have originated both ways, by the natural way and by man´s activity even in the oldest times (thousands of years before our era). They can emerge also when incorrect agrotechnology is used, for instance excessive irrigation or fertilization (ŠUSTYKEVIČOVÁ 1998).

Sometimes old (historic) surface formations could be preserved in soils by the overlapping of new sediments (e. g. burried eolitic sands and loess under recent alluvial sediments for instance in the East of Slovakia, compare KALIVODOVÁ et al. 2002). It is also possible to identify fossile alkali soils that can be lapped over by other soils and historical geology can also determine paleosalinity from clayey rocks even from the sea environment (MIŠÍK et al. 1985). In Hungary 3 to 30 thousand year old fossile salty soils have been found indicating that this soil type also existed in the Carpathian Basin in historical periods (SÜMEGI et al. 2000). No exact data about fossile salty soils in Slovakia has been found and the situation is made more complicated by the fact that the occurrence of salty horizons under the surface can also originate as the accumulation of salts/minerals washed out from top layers. The assumed occurrence of fossile salty soils is indicated so far only in the locality of Raškovce in East Slovakia (BIELEK ex verb., 2004). Saline fossile soils are not even mentioned in specialized works on quartenary development in the Podunajsko region (Danubian lowland).

Quartenary fluvial sediments deposited by water flows (the Nitra river, the Hron river, etc.) in the SW Slovakia create wide alluviums and reach marked thicknesses especially in southern parts of the territory and are rich in ground water (BIELY 1996). For this reason alkali lands in these areas with a good water run-off – without disturbance by man – could not be very widespread, although we cannot exclude any local occurrence of such lands. At the present time solontchak and solonetz form 0,2 % of farmlands in Slovakia (4890 ha, they have not been evaluated separatly, BIELEK at al. 1998, BIELEK ex verb.). Notwithstanding the low acreage, solontchak exists in various types of soils (modal chernozemic, cultisolic, solonetzic, gleyey, brunisolic), similarly as solonetz (modal chernozemic, cultisolic, salty podzolic, fluvisolic, brunisolic) (SOBOCKÁ 2000). According to the data from the right banks of the river Danube, the salt content in the groundwater is lower in the close vicinity of the river and is very alternate at a distance longer than 1 km (GÖCSEI 1979).

It is also useless to look for plant residues typical of alkali habitats in archeobotanical findings from Slovakia. The primary reason for this could be the fact that the documented findings come very often from human settlements. Various introduced and cultivated plants and weeds, especially archeophytes and apophytes can be found among them and also facultative halophytes sometimes occur but it would be too big a step to assume there are alkali soils on this basis. Typical wetland species are also only a rarity, for instance *Schoenoplectus lacustris* or *Eleocharis* spec. from the 16th century

from a storage pit (!) in Trnava. Also archeobotanical findings from localities with salty soils (Iža, Kamenín, Palárikovo, etc.) are without halophytes as a result of which in particular a quantity of seeds from the Roman Age and the early Migration of Nations Period have been preserved (HAJNALOVÁ 1989). We have not found special data about halophyte findings even in Hungarian summarizing archeobotanical works (e. g. GYULAI 2001) and know only a few archeobotanical and palynological analyses that would support our study (SÜMEGI 2005, SÜMEGI et al. 2006). According to these works the pollen composition gives evidence that soil alkalisation in the Hortobágy region was continuous from the Middle Würm to the close of the Holocene and was present in the dominant steppe elements developed at the close of the Pleistocene and it survived throughout the Holocene.

2. Interpretation of geographical, agrohistorical and etnobotanical data

The origin of the so called cultural landscape in Central Europe dates back to the Neolithic period (5th millenium before our era). The Neolithic farmers settled mainly in dry and warm territories in loess and teracce near waters up to 300 m a.s.l. They avoided sloppy locations (LIPSKÝ 1999) as evidenced by the late settlement of the Žitný ostrov region (Csallóköz, Schüttinsel). New forestless ecosystems were created in the cultural farm landscape that had not existed there before (deforestation, grazing etc.) (LOŽEK 1990, LIPSKÝ 1999). The oldest written information about the Danube plains comes from the antique authors. From the mid 5th century B.C, the Greek philosopher and historian Herodotos states that Istros (the Danube) "is the biggest river of all rivers we know and its flow is the same whether in summer or in winter" (*Ίστρος μέν εών μέγιστος ποταμων πάντων των ημεις ίδμεν, ίσος αιεί αυτός εωυτω ρέει καί θέρεος καί χειμωνος*) (ABICHT 1869). If this author´s statement is faithful, the water level could be stabilized either because contrary to the Mediterranean rivers its flow was not seasonal or it could be affected by tributary regulative effects of meandering and continuous forest stands. At that time the Danube area was probably not deforested and not densely settled. At the beginning of our era Strabon states that German tribes occupying the forest area along the Danube were not involved in the farming of animals but rather in grassland farming and therefore deforestation can be expected to have occurred. Plinius senior (1st century of our era) states that Pannonia is rich in *Quercus* acorns (c.f. MARSINA 1998). Agriculture reaches a greater area during the Slavonic and Hungarian period and in the late Middle Ages when a great part of the deforested territories was created.

Looking for geographical names (toponyms, e. g. szík, in the past also „*szék*") can also support the developmental study of alkali habitats (c.f. MOLNÁR 1996a, 1996b). In collections of the oldest medieval documents during 1000-1260, no single statement was found refering to salt marshes or steppes but information about meadows existing in the Slovak part of the Danube Basin appeared, e. g. in 1075 large meadows and clearcut areas for cattle, horses, sheep and oxen ranges along the Nitra and Žitava rivers („*pratis ... latissima enim et longa sunt ad pastum animalium, equiorum, ovium, boum*"), in 1113 meadows at the Nitra river („*in prato*") and in 1253 also in the Žitný

ostrov region („*tertia pars pratorum*“ at Kostolné Kračany) meadows were reported (MARSINA 1971, 1987).

The name of the *Sik*enica brook was known already in the 13th century but its origin can also be different than “*szik*”. For the first time it was mentioned as Scithince (in 1248) and this name was most probably derived from a Slavonic word having the meaning “originated on Sitno”, or the word indicated a locality with “*sitina*“-rush (similar geographic names can be found in Serbian, Croatian and Polish Sitnica, Belorussian Ситниця and Ukrainian Сітниця) (KISS 1988). In the Esztergom Abbacy property listing in 1523 the „river“ Zikinche is shown (read: Sikince) (SOLYMOSI 2002) and in 1742 the same river is named Szikince (KISS 1988). For the sake of completeness we have to add that still in the 1950s meadows with dominant or co-dominant obligatory halophytous grass *Festuca pseudovina* were found at the Sikenica brook (KROPÁČOVÁ 1956). This matter requires further study.

In the Carpathian Basin the first written references to sziks are known from the 15th century (c.f. MOLNÁR 2003, MOLNÁR – BORHIDI 2003). In the works focused on medieval geographical names of the historical Nitra region (prior to 1526) no names referring to sziks were found (FÜGEDY 1938).

In Turkish tax listings deposited in Istanbul, in the so called defters from SW Slovakia from 1663-1664, the name of an extinct settlement “Szíközs Hon, puszta” can be found. According to BLASKOVICS (1993) it is a name of the land-strip in the area of the town of Vráble (in Hungarian: Székes dűlő, Slovak *hon* = Hungarian *dűlő* = English strip of land, “puszta” in this context means: uninhabited). It was a feudal property (beneficium) of Esztergom with an annual income of 500 akchas. It is difficult to determine the word genesis because except for szik (with Hungarian archaic adjective ending -ös) it can also mean affiliation to the Vráble Archiepiscopal Comitatus of Predialists (in Hungarian: „*Verebélyi Érseki Nemesi Szék*”), which operated here from 1424 to 1850. This strip of land is not included in later listing of lands of Vráble, but in the neighbouring community Dyčka a field called „Slaná dolina“ (= Salty Dale) was known (c.f. TRUBÍNI 1994), which is also shown in the recent list of official geographical names of the Nitra district (KOLÁRIKOVÁ – MAJTÁN 1988). But it is necessary to point to that in 1779 among the names of strips of land of the village of Dyčka the land under question can not be found (it might be because of incompleteness of the list). On the other hand in 1834 it is referred to as the „Soós völgy“ (= Salty Dale) (ETHEY 1942). This shows that alkali habitats could exist along the central Žitava (in the southern Vráble region) and it is evidenced by the fact that even today rare obligatory halophytes occur such as *Crypsis aculeata* or *Puccinellia limosa* at Veľká Maňa or Malá Maňa (c.f. HOLUB – GRULICH 1999, MAGLOCKÝ – SVOBODOVÁ 1999). The strip of land called Slaná dolina (and the name of the state enterprise) occurs also at Paňa in the neighbourhood of Dyčka, apparently as its continuation. The field and seclusion name „Slance“ (= salty soils?) is also found at Volkovce (KOLÁRIKOVÁ – MAJTÁN 1988). This region is hilly but we have historical data of alkali habitats even from the colline and submontane regions (c.f. Kitaibel`s obsevations in GOMBOCZ 1945, LŐKÖS 2001; near Tokaj: similar to the Slovakian sziks, c.f. MOLNÁR ex verb.).

In 1735 Mathias Bel states that the Danube Basin is an open lowland suitable for farming but in places is glittering with stone dust. BÖSZÖRMÉNYI (1990) relates this fact to sand and szik. But Bel in his monograph manuscript about Komárno region never mentioned szik, but several times sands (e. g. in the villages of Chotín, Radvaň, Svätý Peter, Semerovce, Bohatá) (BÉL 1996). Geographic characteristics of the Esztergom Archbishopric villages have been preserved from those years (1736-1739), but no a single observation was found about salty lands (DÁVID – POLÓNYI 1980).

At the end of the 18th century some authors describe in some villages large meadows and clearcut areas in places that were later known as large alkali habitats (e. g. at Zlatná na Ostrove, VÁLYI 1796). The change of the meadows ecological gradient could be evidenced by an information from Horná Kráľová where halophytic grasslands can still be found today. In the feudal land and duty register of the Nitra bishop, Ioannes Telegdy, there is shown from 1626 a large meadow called „Füzes rét" (= Willow meadow) with a related tax initiative of 25 carts of hay per year. In 1696 a similar tax is renewed but from 1736 it was only 15 carts per year. It is probably a case of a little broad-mindedness by the church. It may be that this phenomenon points to the fact that the biomass production of the meadow was reduced as the consequence of successive changes from wet meadows (with „willow") towards drier (salty?) grasslands (data from the land and tax registers from ANON. 1626, 1694, 1736). Salty grasslands occurred in the nearby located Hájske where in 1763 land and tax registers show that the inhabitans had „a mown public meadow by less than seven units" („*Mame Luku Obecznu, ale pod Sedem Koszcowo, Kteru na Obecznu Sztranku Kosziwame*"). In the same manuscript sent to the Vienna Court uncut meadows are also mentioned („*Na Lukach jak Ohawa sa nekosziwa*") (ANON. s.d. KSN 46).

It is also necessary to study flood protection and drainage measures taken in the Danube lowland. The first preserved document that orders repairs of the existing dikes and water gates on the Žitný ostrov comes from 1569 and gradually, up to the 19th century, a great part of this territory was drained (FÖLDES 1999). The first protected settlement on the banks of the Danube could have been settled by the Celts and was situated near today`s Bratislava at the Danube. Drainage works proceeded slowly on the alluvium of the Váh down stream, but the river was not sufficiently drained even at the beginning of the 19th century. In 1822 Alois Mednyanský, baron, in his book „*The picturesque travel down the Váh*" wrote poetically of the last section of the journey: „As an old man staled by life the Váh snails and crawls slowly in the last section of is its flow. Across marsh landscapes and never dried swamps caused partially by their own waters and partially natural springs, leads the way of the river" (in the Slovak version: „*Ako životom omrzený, nič už od sveta neočakávajúci starec plazí a vlečie sa pomaly a lenivo Váh v poslednom úseku svojho toku. Cez močaristé kraje a nikdy nevysychajúce bahniská spôsobené sčasti vlastnými vodami, sčasti prírodnými prameňmi vedie jeho cesta ...*") (MEDNYANSKÝ 1962).

But the Danube Basin was gradually deforested. According to archive documents the vast forests of oak on the Žitný ostrov were preserved till the beginning of the 19th century, their last remains disappeared approximately in the 1960s (VARGA 1989). According to tradition the robust oaks were the biggest trees in the Danube lowland (CSIBA – PRESINSZKY 1993). Forests have been changed into arable lands and meadows. In the period of villeinage abolishment in the mid 19th century, meadows were

particularized and often drained. It certainly supported the origination of salty lands. In 1858 Ipolyi pointed to that especially in the central part of the Žitný ostrov noting that year by year "dry deserts" emerged ("… *kietlen sivataggá változik*", IPOLYI 1993). In other place he wrote that on the lower Žitný ostrov there were large meadow areas and pastures. In 1935 it was reported that in the eastern part of the Žitný ostrov there were hypertrophied heavy, clayey and partially salty soils that could be farmed only with difficulties, their deep cultivation was impossible and in dry weather they were cracked and after rainfalls they changed into a sea of mud (MACHNYIK 1993).

The history of danks drainage between the rivers Váh and Nitra is also interesting. The channel called Dlhý kanál (also Hosszú-kanális or Cergát = Long Channel) was built here and its construction, according to the local chronicle at Andovce, was still not finished in 1890 (VÁGVÖLGYI 1998). It is interesting to list the villages situated along the channel: Hájske, Jarok, Horná Kráľová, Močenok, Jatov, Tvrdošovce, Palárikovo, Andovce – they are all villages with alkali habitats. The channel building could not start the soil salnisation because the geographical names referring to sziks are older than the artificial drainage (see below). Probably the region had a bad run-off of inner water and the szik areas have an older historical origin. The Dlhý kanál channel at Andovce passes across the locality „Száraz-rétek" (= Dry meadows!) to the cadaster district of the town of Nové Zámky and mouths into the Nitra river.

Let´s go back to direct archive evidence of alkali habitats. In 1848 Fényes already mentioned szik soils at Zlatná na Ostrove („its soil except a small territory of sziks, is a fertile black clay", „*Földe, kevés székes területet kivéve, termékeny fekete agyag*") and at Okoličná na Ostrove („its soil is only partially sandy and szik", „*főlde csak kis részben homokos és szikes*") (FÉNYES 1994). There also appeared cadastre names with denominations relating to alkali habitats. In 1764 (!) and 1835 a strip of land called „Sósok" (Salty) at Moča appeared (actual Slovak name: „Slané" = Salty). This name was also preserved after 1899 as well as „Nagy-sós" (Big salty) and „Fehér-mező" (White meadow). According to BÖSZÖRMÉNYI (1990) those names stand for szik. In 1734 (!) (CZIBULKA 2002) and also in 1847 in property listings at Tvrdošovce (ANON. s.d. KSN 187, 188) a meadow called „Szeges" was shown (Hungarian „*szeg*" = nail or land/field edge/corner, but it could be a phonetical development of szék as well), in 1856 as „Szegyes" (at present also „Szegyes", NAGY 2000). „Szeg" can be also found in other szik-site names, e. g. „Hanszeg" in Veľký Meder (old Hungarian „han" = wetland, c.f. „Hanság" is also a name of a wetland region near the salty Neusiedler See/Fertő-tó in Austria/Hungary). In Tvrdošovce, fragments of alkali habitats have been preserved up to the present day. Also in the mid 19th century the Tvrdošovce part of the strip of land known as Akomány (now officially: Akomáň or Okomáň) was referred to, see later at Šurany. Szeg In 1859 on the cadastral map of Hájske a strip of land called „Székes Legellő" (= Szik pasture) is shown, later rewritten to „Széki". On another map from 1863 it looks like „Sziki" (both maps: ANONYMUS s.d. KSN s.d., map 77). Today it is called „Siky" (ČUTRÍK 2003). At Močenok in the mid 19th century geographic names „Széki Major" (= Szik country estate) and „Széki Földek" (= Szik fields) were shown, in 1862 „Szék" (ANON. KSN 166). Salt steppes at Močenok are also called „Sziky". In 1863 sziks were mentioned at Veľký Kýr („Kis széket", „Alsó-széket", „Felső-Sziket" = Small szik, Lower szik, Upper szik) (SZŐKE 1993). In this case these names could also be the historical names of the Nitra river islands (in

Hungarian: sziget = island), but N. CSÁSZI (1993) refers to them as szik fields. Today the forms „Szíket", „Kisszíket", „Nagyszíket" (Hungarian kis = small, nagy = big) are used. At Kamenín there was a strip of land named Sósok (Salty) (NAGY 1988) but the actual szik is called „Alsó-rétek" (= Slovak: Dolné lúky = Down meadows). Another „Sósok" was at Gbelce. In Gbelce, according to LISZKA (1992), the soil was szik, in the past more humid, later dried (drained?).

The name of the salt marsh at Iža – „Bokros" or „Bokroš", is noteworthy - it means a territory covered with shrubs (Hungarian bokor = shrub, bokros = bush). Bushes could exist here on less fertile soils (although we can not fully exclude shrubby willows before the drainage of the territory). Some geographical names of szik steppes relate to a reduced drainage of the former wet territory, for instance at Ľubá in the catchment basin of the Parížsky potok, the locality „Tó-völgy" (= Lake valley) (c.f. MRAVÍK 1968) or „Teknyős-völgy" (= Slovak: Korytnisko = Trough/River-bed Dale) and its continuation „Párizs-völgy" (in Slovak: Parížska dolina = Paríž valley) in Diva. The geographical name of „Irtoványi rétek" or „Čistiny" in Slovak (= Clearings) at Kamenný Most apparently refers to forestless (deforested) vegetation, a puszta site at Andovce, „Laposságí" (= Plain) or at Pataš, „Öreg Lapos" (= Old Plain) speaks about the territory geomorphology (c.f. VÁGVÖLGYI 1998). The „puszta" (see in the introduction) is included in geographical names like „Csenke puszta" (in Mužla-Čenkov) or „Ekeli puszta" (in Okoličná na Ostrove), the „gyöp/gyep" (= grassland) in „Ócsai gyöp" (= grassland in Zemianska Olča) or „Határ-gyöp", „Pokolfa-gyöp", „Halom-gyöp" (in Tvrdošovce, c.f. CZIBULKA 2002). The salt steppe at Šurany known as Akomáň was in 1839 and 1842 mentioned as Akolmány (ANON. s.d. KSN 76), whereby „akol" is in Hungarian a herd of sheep and „mány" (also „mál") archaic Hungarian forestless area (the component part „-máň" is contained in the geographic names of the Nitra town, like Čermáň, Ravasmáň, etc.). According to the above quoted archive documents on the territory of the strip of land Akomáň, clearcut areas dominated as well as on the neighbouring strips of land Nádaskút (Reed well) and Tolmácz. The above mentioned word „akol" was used also in other szik names, e. g. „Akóhelye" (= akol-site) in Gabčíkovo. The „Kis-Csík" and „Nagy-Csík" (in Slovak: Malé Čiky and Veľké Čiky) land names in Šurany might mean Small and Big Szíks or Small and Big Water-flows.

In 1865 salty sites are reported near Jatov, salt marshes at Šaštín and Bori (?) in the Záhorie region and also in Tvrdošovce and Jelenec („*Ausgedehnte salzige Stellen kommen bei Sassin, Bori, Tardosked and Ghimes, doch die beiden letzteren Angaben werden sich sicherlich als unrichtig herausstellen*", KNAPP 1865). As you can see in the original German text, Knapp added, that the last two ones must be mistakes. We can confirm, that Tvrdošovce is known for its alkali habitats but the hilly Jelenec less so, however in the neighbouring village, in Kostoľany pod Tribečom *sal nitra* was collected for gun powder production (see below). In the villages of the Medzičilizie region (also Csilizköz) several geographical names can be found with a "salt/salty" adjective (HORVÁTH – TELEKINÉ NAGY 2000) but the alkali habitats of this region have been completely degraded, e. g. „Sós-hát" (= Salty elevation) in Kľúčovec and the neighbouring „Sósháti-híd" (= Bridge at the Salty elevation) in Medveďov, „Sós-domb" (= Salty hill) in Ňárad. According to these names, the alkali fields were on elevations (not directly in the deepest floodplain, where the water level was high during all the year).

The „Sós-tó“ (in 1889 „Soóstó“, in 1909 „Soós tó“ = Salt lake) is known in Sap. After HORVÁTH – TELEKINÉ NAGY (2000), in the last case, Soós is a family name(?).

Gradually first records of szik plant species from the Komárno region were published, too. For instance from 1848: *Salicornia* sp., *Plantago maritima*, *Lepidium perfoliatum* etc. (FÉNYES 1994). In 1865 even more halophytic species were reported from the historical Nitra county, including also older observations: *Acorellus pannonicus* at the Váh and Nitra rivers, *Camphorosma annua* in Tvrdošovce and Jatov, *Plantago maritima* in Zbehy, Tvrdošovce, Jatov, Močenok, *Artemisia santonicum* L. in Jatov, *Scorzonera parviflora* in Tvrdošovce and Adamovce(?), *Tetragonoglobus maritimus* in Rybník near Skalica, Horný Vinodol, Tvrdošovce and Močenok, *Trifolium fragiferum* in Dvorníky, Tvrdošovce, Selice, Močenok etc. (KNAPP 1865). Pantocsek´s list from the former Nitra county from 1898 gives these halophytes: *Achillea asplenifolia*, *Acorellus pannonicus*, *Artemisia santonicum*, *Atriplex littoralis*, *Bupleurum tenuissimum*, *Camphorosma annua*, *Centaurium littorale*, *Crypsis aculeata*, *Lepidium perfoliatum*, *Lotus tenuis*, *Matricaria recutita*, *Melilotus macrorrhizus*, *Plantago maritima*, *Puccinellia distans*, *Spergularia salina*, *Taraxacum bessarabicum*, and *Tripolium pannonicum* (PANTOCSEK 1898). The species list refers more to solontchaks than to solonetzes but unfortunatly we have no exact locality characteristics (the solonetz is more typical for the alkali habitats near the Danube river).

The first half of the 20th century was rich in data on the discovery of alkali vegetation mapping and documenting their degraded or relatively good conditions (KRIST 1935, 1940, KLIKA – VLACH 1937, KRAJINA 1938). In the 60-ies it was possible to find a still well conserved vegetation pattern of selected salt steppes, studied in detail in the Žitný ostrov region [Artemisieto – Festucetum pseudovinae Soó (1933) 1945 = at present Artemisio santonici – Festucetum pseudovinae SOÓ in MÁTHÉ 1933 corr. BORHIDI 1996, with “stages” or “variants” of *Camphorosma annua*, *Plantago maritima* and *Tripolium pannonicum* in Zlatná na Ostrove, Komárno, Veľké Kosihy and Okoličná na Ostrove, KRIPPELOVÁ 1965]. The halophytic plant communities of (Czecho)Slovakia were syntaxonomically classified by VICHEREK in 1973. In the second half of the 20th century as a result of changes in management, the authors already gave details only of degradation of halophytous associations and the decline of these species on those sites, for instance:

- Kamenínske slanisko (Kamenín) – plastering, ploughing away, fertilisation, hydroamelioration (SVOBODOVÁ, ŘEHOŘEK 1985).
- Čistiny (Kamenný Most) – compost dump, straw dump, remains of a scrap-heap, closeness of railway, traverse of heavy mechanisms, attemps of intense agricultural utilisation or amelioration (SVOBODOVÁ, ŘEHOŘEK 1988).
- Bokrošské slanisko (Iža) – afforestation (KLOKNER 1985), at present also waste dump.
- Zlatná na Ostrove and surroundings – ploughing, afforestation, clay excavation, amelioration (KRIPPELOVÁ 1965).
- Dérhídja/Tér-hídja (Veľké Kosihy) – drainage, access grazing, straw storage, ruderalisation (SVOBODOVÁ – ŘEHOŘEK 1992).
- Tvrdošovce – waste, football grounds, earth works, herbicides (SVOBODOVÁ – ŘEHOŘEK 1992).

- Sziky (Močenok) – recultivation (ploughing), fertilization by excrements, soil excavation, burning out(?), jubbing out divet for horticulture (SVOBODOVÁ 1992, SVOBODOVÁ – ŘEHOŘEK 1992).
- Scattered salt steppes in the area from Hájske and Horná Kráľova to Nové Zámky and Šaľa – ploughing away, trucking out excrements, jubbing out divet for gardening purposes (SVOBODOVÁ – ŘEHOŘEK 1992).
- Akomáň (Šurany) – intense ranging, weed expansion (SVOBODOVÁ 1999).

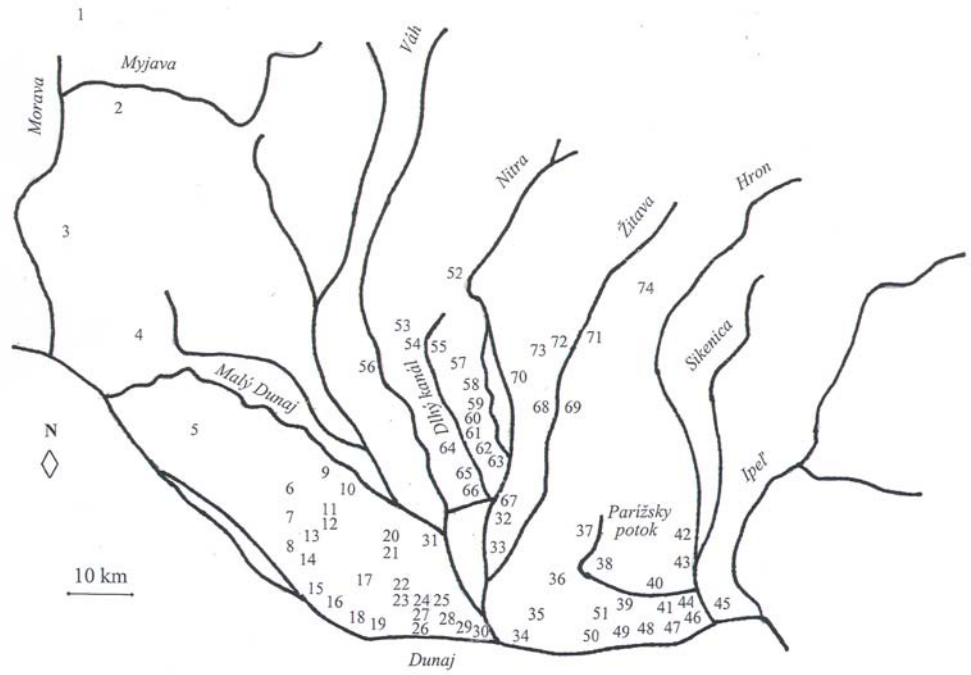
The fragments of alkali habitats are very rare and small but of different type. Most of them are of solonetz type (e. g. Kamenín, Iža, Pavol in Zlatná na Ostrove), other ones seems to be more solontchak steppe type with a higher sand content in the soil, (e. g. part of Tvrdošovce or Močonok). However in Močonok solonetz soils seem to be dominant, they originated on alluvial deposits, mainly in depressions with high mineralized underground waters (c.f. HANES 2001). We can find alkali steppe-wood-like habitats (Iža), steppe meadow (the locality Szirányi-tag in Tvdošovce), dried saline wetland (Búč), partly desalted habitat with an half-artificial mosaic in development (Pavol in Zlatná na Ostrove). Actually no saline habitat used to be flooded but in the past some of them could be covered by water for a long time (c.f. in 1936 the lowest parts of the locality Tvrdošovce had been flooded untill the second half of May, KRIST 1940).

The salt lakes might be more common in the past according to the military maps of the Mary Theresa period in the 2nd half of the 18 century (e. g. Kamenný Most, Diva?, Búč, Tvrdošovce), there remained only two small fragments of them in Tvrdošovce (ELIÁŠ jun. ex. verb) not registered as official habitats in Slovakia. Some small artificial pits/depressions (called "*pangét*", c.f. CZIBULKA 2002) had been dug by workers when the railway was built in Tvrdošovce before 1850 and small artificial salt lakes after brick-clay excavation could be also find in the Žitný ostrov region even in the 1960s (KRIPPELOVÁ 1965).

The study of other artifical works in szik habitats need more study (elevated cart-way? in Dérhíja/Veľké Kosihy etc.). There were many alkali habitats that completely or almost completely disappeared, e. g. Bíňa, Bodza, Boheľov, Chotín, Dolný Štál, Dubník, Horný Štál, Komjatice, Kravany nad Dunajom, Martovce, Nesvady, Nová Stráž, Obid, Okánikovo, Okoč, Opatovský Sokolec, Pataš, Pribeta, Rastislavice, Tôň etc. (we excluded disappeared localities mentioned in other parts of this paper and sites known only for their saline soils in arable land, c.f. KRIST 1940, VICHEREK 1973). Some saline habitat fragments have been also known near Svätý Jur (locality Šúr) on the sandy soils of the Záhorie region (localities Kripolec or Kostolište near Malacky and at the Morava river). Also a site called „Slanisko" (= szik in Slovak) is mentioned South East from Malacky (Fig. 1).

Fig. 1. Localities mentioned in the text with sure or probable historical occurrence of saline habitats in SW Slovakia (number of locality, Slovak name of locality, historical Hungarian name)

1. ábra. A szikesek szövegben említett biztos és valószínű történelmi előfordulásai Délnyugat-Szlovákiában (sorszám, szlovák helységnév, történelmi magyar helységnév)



Magyarázat / *Legends*: 1. Skalica (Szakolca), 2. Šaštín (Sasvár), 3. Malacky (Malacka), 4. Svätý Jur (Szentgyörgy), 5. Štvrtok na Ostrove (Csallóközcsütörtök), 6. Kostolné Kračany (Egyházkarcsa), 7. Vrakúň (Várkony), 8. Gabčíkovo (Bős), 9. Dvorníky (Udvarnok), 10. Trhová Hradská (Vásárút), 11. Horný Štál (Felistál), 12. Dolný Štál (Alistál), 13. Boheľov (Bögellő), 14. Pataš (Csilizpatas), 15. Ňárad (Csiliznyárad), 16. Sap (Szap), 17. Veľký Meder (Nagymegyer), 18. Medveďov (Medve), 19. Kľúčovec (Kulcsod), 20. Opatovský Sokolec (Apácaszakállas), 21. Okoč (Ekecs), 22. Bodza (Bogya), 23. Tôň (Tany), 24. Zemianska Olča (Nemesócsa), 25. Okoličná na Ostrove (Ekel), 26. Veľké Kosihy (Nagykeszi), 27. Okánikovo (Szántóér), 28. Zlatná na Ostrove (Csallóközaranyos), 29. Nová Stráž (Őrsújfalu), 30. Kománo (Komárom), 31. Kolárovo (Gúta), 32. Nesvady (Naszvad), 33. Martovce (Martos), 34. Iža (Izsa), 35. Chotín (Hetény), 36. Pribeta (Perbete), 37. Dubník (Csúz), 38. Strekov (Kürt), 39. Gbelce (Köbölkút), 40. Diva (Gyiva), 41. Ľubá (Libád), 42. Bíňa (Bény), 43. Kamenín (Keménd), 44. Kamenný Most (Kőhídgyarmat), 45. Kamenica nad Hronom (Garamkövesd), 46. Štúrovo (Párkány), 47. Obid (Ebed), 48. Mužla (Muzsla), 49. Kravany nad Dunajom (Karva), 50. Moča (Dunamocs), 51. Búč (Búcs), 52. Zbehy (Üzbég), 53. Hájske (Köpösd), 54. Horná Kráľová (Felsőkirályi), 55. Močenok (Mocsonok), 56. Šaľa (Vágsellye), 57. Mojmírovce (Ürmény), 58. Veľký Kýr (Nagykér), 59. Komjatice (Komját), 60. Rastislavice (Dögös), 61. Jatov (Jattó), 62. Tvrdošovce (Tardoskedd), 63. Šurany (Nagysurány), 64. Selice (Sókszelőce), 65. Palárikovo (Tótmegyer), 66. Andovce (Andód), 67. Nové Zámky (Érsekújvár), 68. Malá Maňa (Kismánya), 69. Veľká Maňa (Nagymánya), 70. Horný Vinodol (Felsőszőlős), 71. Vráble (Verebély), 72. Dyčka (Nemesdicske), 73. Paňa (Nemespann), 74. Volkovce (Valkóc)

In compliance with present knowledge we can say that solontchaks are not very fertile and if they are to be used for agriculture they have to be "improved". They can mainly be used for grasslands (BIELEK et al. 1998). The traditional (popular) soil classification on the Žitný ostrov was judged by Liszka (2002) taking into account previous research of SÁNDOR (1989) and GUDMON (1992). The farmers of the Žitný ostrov region, in the villages neighbouring with Dunajská Streda (Trhová Hradská, Vrakúň, Kostolné Kračany, etc.) distinguished three kinds of soils:

- "dombfődek" (soils on elevations) which were the most fertile, due to the thickeness of the mould layer and their not being endangered by ground waters,
- "laposok" (plain soils) having the worst quality as a consequence of underwatering, and
- "ígevínyes/égevényes fődek" (burned-out soils), which were dry and "stony".

In our opinion, it is quite possible that salty soils did not occur in this area or they belonged to the last category because in any case they were not really stony soils (such soils simply do not exist in this area and at best only bigger fractions of gravel may be present in the soils). In the neighbourhood of Kolárovo sandy soils were referred to as such because "plants will burn in them". The word "égevényes" is recorded in Mary Theresa´s era land and duty registers from 1768 from the village of Štvrtok na Ostrove, where it is stated that they are soils from which in dry years the crop "burns out" (SILL 1996).

The low fertility of these soils and difficulty farming them was known by the older farmers on the basis of their own experience, they did not have to have scientific information. They often avoided these soils or used them for pasture for sheep preferring low grasses. SZABÓOVÁ (1989) states that alkali vegetation located in the Komárno district was of grazing character (e. g. Bokroš at Iža and Dérhídja at Veľké Kosihy) and as a component part of their management she recommends sheep grazing. The first datum evidencing sheep breeding along the Danube in Slovakia is from 1156, when a sheep fold was recorded at Strekov (MARSINA 1971). This of course does not mean that there were salty soils there but only a possibility that sheep could have grazed there on salt grasslands (salty habitats were known here in the 20th century).

After the expulsion of the Turks (16th-17th century) there were about 1.400.000 sheep on the territory of Slovakia. This is evidently also related to the previous Walachian colonization (from Romania and Ukraine) in the 14th-17th centuries when sheep breeding was a common occupation not only in the mountain areas abut also in deforested lowlands (in 1567 King Maximilian ordered sheep herds to be excluded from local forests). In Slovakia the manufacturing of high quality drapery was first established in 1666 in the lowlands of the Žitný ostrov (in Hubice). Big sheep studs were also established at the lower Považie and Ponitrie (the downstream reaches of the Váh and Nitra rivers). In the 18th century the village of Mojmírovce kept 24.000 sheep, but there were big herds in Palárikovo (alkali habitats!) and in other places (VONTORČÍK 2001a). Strict articles of the Žitný ostrov shepherd guild have been preserved for us from 1717. In the mid 19th century in plain areas of West Slovakia individual villages kept from 300 to 1000 sheep (HORVÁTH 1987). A big reduction in sheep numbers was recorded in the second half of the 19th century, going down by 56,4 % between 1874 and 1911 (VONTORČÍK 2001b).

After the creation of new drainage areas the number of sheep could have increased, but it did not happen (there were only a few secondary alakali habitats and the economies of sheep breeding got worse). Agro-historical studies state that the number of sheep in the south-west of Slovakia was higher in the area between the river Váh and Hron compared to the Žitný ostrov and they explain that this is due to the water balance on those meadows (FEHÉRVÁRY 1992). It would be difficult to reconstruct the species composition of meadow stands but probably they were sub-xerophilous mea–dows, since the rich meadows were grazed by cattle and pigs were kept in forests. This is because other domestic species were not able to utilize fescue which has a lower nutritional value. According to the data from the Mliečno near Šamorín environs, the cattle, horses and pigs were raised on islands (they were able to swim from one island to another) but sheep cannot swim so they were kept only on meadows, in bushland and on forest edges (CSIBA – PRESINSZKY 1993). Different historical breeds and species preferred and were suited to different plant habitats (STERBETZ 1995). At Gbelce on the „Sós" (Salty) locality according to elderly people „not a grass could grow there", „there was only grass of *Festuca pseudovina*, good for nothing, that even a scythe could not cut off " (*„fű sem igen termett benne*", *„semmi, veresfarkú fű volt benne, nem vitte a kasza*", LISZKA 1992). In the areas with a more valuable glycophilous grass, meadows could be larger than the area of arable land and/or pastures. The largest meadows of such type could be at Kolárovo (c.f. ANGYAL 1992).

Near Štúrovo at the beginning of the 1950s the production potential and economic utility of local grass stands was studied in detail (KROPÁČOVÁ 1956). Within the group of unflooded meadows the ecological grade of *Festuca pseudovina – Poa angustifolia* was specified and within this group a halophytic plant community type, *Festuca pseudovina – Poa angustifolia*. Within the whole grade even 12 % representation of poisonous species was found and they were the meadows cut twice (!) with an occasional pasture (in spring sheep and goats, e. g. at Kamenín, cattle at Kamenica nad Hronom). The study also points to the fact that with regard to a low meadows productivity they were often ploughed, in other places deserted and grown over with weeds From those times there is a reference about the remains of the salty fields at Mužla, but since that time the salt habitats have become completely extinguished. Within the pastures the ecological grade of *Agrostis stolonifera*, type *Agrostis alba – Puccinellia distans* (known also from Mužla) and a steppe pasture *Festuca pseudovina* had been classified. In the summer the economic value of these stands was very low even insignificant. KROPÁČOVÁ (1956) recommended either to start with early spring pasture in these areas or to plough them up (it´s a pity but many valuable alkali habitats finished like this – author´s remark).

Salts precipitated on the surface of soil and its accumulation in their upper layers were of different chemical composition. Some salts crystallised on the soil surface with a higher nitrates content, usually as the consequence of accumulation from the animal excrements, were suitable for production of sal nitra (also sanitra) after a treatment (naturally originated mineral inflorescens are extremely rare even in Hungary). A very old datum from sziks has been found at Močenok and Horná Kráľová, where in 1561 the Royal Chamber wanted to exploit these salt steppes for production of gun powder. On the sziks of those places, in 1624 and/or 1626, there were 4 workshops for processing the sal nitra (GERGELYI 1965, JUDÁK – HANKO 1994, TAKÁČ 1994). Juraj Fándly

in 1792 in his distinguished work „Industrious home and field manager" („*Piľní domajší a poľní hospodár*") recommends the use of sal nitra for fertilisation and overruns even the German chemists studying mineral fertilization: „Skilful farmers teach that both in the earth and in the manure the same sal nitra, nitra salt (sal fixum) can be found which attracts another not so boiled away manure salt (when they mix together in the soil). Both salts saturated in the soil increase the crop yields." („*Kunštovni hospodári učá, že jako v zemi, taktéš aj v hnoji nachádza sa istá saňitra, saňitrová soľ, menovaná subtiľnejšá sol (Sal Fixum), od náturi prepáľená vivarená soľ, která druhu ešče ňe tak silno vivarenu hnojnu soľ (keď sa spolu v zemi míšajú) k sebe priťahuje. Této dve soli v zemi zahráté, zaparené že mnoho úrodám k jejich zrostu dopomáhajú*") (FÁNDLY 1990a). He recommends this salt in 1793 for removal of warts (FÁNDLY 1990b). As follows from the quotation sal nitra occurred in the soil where it deposits when the earth is saturated with manure. Such deposition/precipitation was possible only in places where the water balance was similar to salty soil processes.

Later sources (from 1825) give details of sal nitra production and also gun powder production from soil saturated with the manure and urine of domestic animals (probably artificially) at Drážovce near Nitra (GERGELYI 1991). These sources should clarify for us the zoogenic origin of these salts in soil, which are different from salts from sziks, but the process of deposition of salts from soils could be very similar. These salts originated also apart from plains, e. g. at Drážovce they utilized the raw material from Mechenice (GERGELYI 1991) and the gun-powder from local sources was also produced at Kostoľany pod Tribečom (JAHN ex verb., 2004). Similarly we can not determine with certainity whether the medieval salt storage house of Esztergom Archbishopric at Kamenný Most (MRAVÍK 1968) did not have anything in common with the local alkali habitats (today Čistiny), it is a question as to why they had placed a salt storehouse right in the place where fragments of salty fields have been preserved up today. On the other hand it was at the Trans-European Salt Way and therefore we guess it was independent of the sziks. At the beginning of the 19th century, near Bratislava, on the southern river-bank of the Danube (in the former Moson district), soda-szik salt was collected („*Soda, szék-só, wird ... aus den basigen Salzlachen, Zicklachen, gesammelt*", CSAPLOVICS 1829). The different salt efflorescences in the Pannonian region on soil surfaces have been evaluated in SZENDREI – TÓTH (2006).

Discussion

Geobotanical literature has not solved the question of authenticity of alkali habitats in Slovakia in a satisfactory way till today. The question whether the Slovakian halophytic plant communities are native (thousands of years old primary alkali vegetation) or whether they appeared after the drainage and the removal of forests (secondary alkali vegetation) has existed for a long time (c.f. MICHALKO et al. 1987). The origin and development of alkali habitats in the Carpathian Basin was most studied by Hungarian botanists since salty fields occupy large areas in this country. Knowledge from the Hungarian Tisza region is not applicable in all cases for SW Slovakia, because of the different soil-climatic conditions. The oldest authors (e. g. KERNER 1863) assumed that alkali vegetation along the Tisza river were the extended western

territories of the Pontic flora (the species expanded there over the past 17.000 years because before there were not favourable climatic conditions for them, sensu KRIPPEL 1986), and later it was assumed that their occurrence was related to man´s activity which artificially created and maintained the steppe vegetation (e. g. RAPAICS 1916).

A two-phase distribution of alkali vegetation was for the first time mentioned by BOROS (1926, 1929), who said that they formed an original component of the original vegetation and man only assisted in their broader expansion. Till that time there was discussion only about the occurrence of primary alkali vegetation on clearings of halophytous oak woods ("sziki tölgyes") and alkali habitats at marsh edges that originated by deforestation when pastures were created and in the course of drainage works on the territory. KRIST (1940) said that SW Slovakia was dominated by forests ("*pokrytá z valné části lesy*") and the steppe vegeteation had been developed artificially ("historically"). SOMOGYI (1965) by a more detailed study of a lowland country's dynamics came to an opinion that alkali territories in our geographical space existed from the beginning of the Holocoene. Although continuity did not have to be direct, it could be interrupted several times by desalinization of soil and later followed again by the appearance of solonetzes and solontchaks.

SÜMEGI et al. (2000) state that alkali habitats in the Carpathian Basin have existed without a break since the last glacial period and there is direct evidence for the continuity of alkali soils since the Pleistocene. It can be confirmed by stands with a relatively high biodiversity and representation also of endemic species, not only of plants but also of animals. It is supported also by the occurrence of overlapped fossile soils. According to KRIPPEL (1986) the steppe or forest-steppe vegetation in Slovakia is natural and forest steppe, in his understanding, is a mosaic of decidious trees and steppes and not as a forest with steppe elements in the undergrowth. According to the origin we also have to distinguish the steppe "sensu stricto" (even if partially changed by man) and "cultural steppe", as an unforested synantropophytous formation. We have to point to the fact that the mosaic of steppes and forests is often within strict boundaries, practically without transient edges (e. g. alongside an oak forest there can be a steppe or a marsh without any transition because seedlings can not survive in another habitat, c.f. VARGA et al. 2000). It was from the Neolithic era till the first millennium before our era steppe could be maintained by man. Steppe gradually synantrophized and the original steppe flora remained preserved in small territories only, including alkali grass-herbal vegetation. In the conditions of Slovakia we can find both (Euro)-Asian and Sub-Mediterranean halophytic species (c.f. VICHEREK 1973).

MICHALKO et al. (1987) suppose that in the place of present salty lands in Slovakia, similarly as on the Hungarian Great Plain (Nagyalföld), the forests could be like the association Festuco pseudovinae – Quercetum roboris (MÁTHÉ 1933) SOÓ 1960, although they do not exist in the Slovakia of today (this hypothesis is quite doubtful, remark of the auhor). Associations of the alliance Scorzonero – Juncion gerardii (WENDELBERGER 1943) VICHEREK 1973 can be either primary or derived. Scorzonero parviflorae – Juncetum gerardii (WENZL 1934) WENDELBERGER 1943, is regarded as an association of terrestrisation of marshes, Caricetum divisae SLAVNIĆ 1948 is regarded strongly as antropogenized (e. g. by an increased Nitrogen contents) and Agrostio – Caricetum distantis RAPAICS ex SOÓ 1938 as a replacement association of alluvial forests. When dealing with salt steppes (alliance Festucion pseudovinae SOÓ 1933)

they state that these originated by complete deforestation, drainage and grazing. Similarly VARGA – VARGÁNÉ SIPOS (1999) that associations of the alliance Festucion pseudovinae originated in the place of forest steppes, and/or floodplains.

According to latter research on the „Hortobágyi-puszta" in the East of Hungary both primary and secondary alkali habitats occur as well as their transient forms according to the degree of exploitation (compare the introduction). MOLNÁR (2003) and MOLNÁR – BORHIDI (2003) on the basis of factual studies at the Tisza river region state that secondary alkali steppes originated from floodplain wetlands, which as a result of drainage changed into the steppe and szik vegetation. The authors also point to the fact that a large part of forest-steppe oak woods on salt lands (Festuco pseudovinae – Quercetum roboris) including their grass-herbal clearings (Peucedano – Asteretum sedifolii SOÓ 1947 corr. BORHIDI 1996) are dried out or drying out floodplains. On the basis of literature data and field research, the cited authors say that these alkali forest steppe mosaics have originated from hard-wood riparian mixed forests (though they also assume that the driest parts of these woods are primary). The originality of *Artemisa* and *Camphorosma* steppes in the woodland openings is questionable (c.f. MOLNÁR 1996a, 1999, 2003, MOLNÁR – BORHIDI 2003). They look for original "sziks" in territories which were not directly affected by floods and were without drainage. These habitats are relatively stable since the salt acummulation is a fast process but the wash up is slower. After a break of extensive grazing the species composition would be changed only slightly. After degradation the regeneration is quick, because species are adapted to disturbance (that is, to regenerations after them), propagule source is close to and adventive species can not stand extreme conditions of well established salt lands. Dynamic processes in them are therefore short term and reversible. The origin of secondary alkali steppes was supported by evidence from an „experiment by chance" at a newly built dam (MOLNÁR 2003, MOLNÁR – BORHIDI 2003).

In 2004 seedlings of *Quercus robur* on Hortobágy alkali steppes were discovered close to an artificially planted forest Farkas-sziget (Ágota-puszta, Püspöskladány) and equally far from oak woods at the bridge Zádor-híd (near the town of Karcag) (FEHÉR unpubl., 2004). Local germination of acorns was found at solitudes ("tanya"). Is it a renewal of the orginal forest or is it a coincidental (temporary) germination? Afforestation (thickening of a forest stand) of a salt forest-steppe vegetation is known from Hungary. The mosaic of a woody stand could be created first of all in a place where the depth of a salt layer was more than 80-100 cm. In places where the salt content was in higher layers, steppe formations dominate. The mosaic of salty oak woods and the association of Peucedano – Asteretum sedifolii were considered earlier as primary alkali vegetation, later as (partly?) secondary (dried out) (c.f. MOLNÁR 2003, MOLNÁR – BORHIDI 2003). They could exist also southward from the Danube river in the neighbourhood of the Slovak Danube lowland region or Lesser Plain (Kis-Alföld, Répce floodplain) (e. g. MOLNÁR et al. 2000, MOLNÁR, in verb) (more data below). A possible but bad rooting of wood species on alkali steppes can be seen in an experiment with afforestation of Bokroš salt steppe at Iža, where in 1959 an elm stand did not root and poplars rooted partially. After re-ploughing in 1978, it was afforested with *Acer pseudoplatanus, Alnus glutinosa*, *Quercus robur* and *Tilia cordata,* and these species rooted again only partially (KLOKNER 1985). Neither poplar plantations were very succesful in Zlatná na Ostrove and Palárikovo (KRIPPELOVÁ 1965).

How therefore to distinguish primary and derived salt lands? According to MOLNÁR (1999, 2003) and MOLNÁR – BORHIDI (2003) the differences can be seen for instance in that on primary salt fields the vegetation mosaic is more multiform, more contrasted, non-homogeneous, the salt lands geomorphology at the microrelief level is more expressive. For such alkali areas a high biodiversity with a number of specialists is typical. The differences can also be seen by the fact that primary alkali habitats are not of alluvial character (except for some relict abandoned meanders) and afforestation is very insignificant here, and/or the woody plants growth is very slow. Biodiversity, contrast richness of landscape, vegetation mosaics and local historical data are the most important indicators to distinguish primary and secondary alkali habitats. It was about the solonetz lands. The solontchak areas are always regarded as primary, flora is diverse, endemic species are common. There are no secondary solontchaks, drained areas turn into alkali meadows or characterless dry grasslands. The following species are typical for primary alkali habitats *Camphorosma annua*, *Oenanthe silaifolia*, *Phlomis tuberosa*, *Pholiurus pannonicus*, *Puccinellia limosa*, *Thalictrum minus* (also *Plantago schwarzenbergiana*, *Rorippa sylvestris* subsp. *kerneri*, *Sedum caespitosum* and *Suaeda maritima* (correctly: *S. pannonica*) but these species are not listed in the Slovak checklist of vascular plants, c.f. MARHOLD – HINDÁK (1998), for derived (secondary) *Achillea setacea*, *Artemisia pontica*, *Cichorium intybus*, *Galatella punctata*, *Inula britannica*, *Iris spuria*, *Jacea pannonica*, *Lepidium ruderale*, *Lythrum virgatum*, *Peucedanum officinale*, *Plantago lanceolata*, *Potentilla reptans*, *Scleranthus annuus* and *Viola pumila* (*Bassia prostrata* is not included in MARHOLD – HINDÁK 1998).

Taking into account the above facts we may say that in the territory of Slovakia species typical of primary and species typical of derived alkali habitats are found as well. The above list can not be accepted as a special guide because the species of alkali habitats are stress-tolerating and may occur in secondary habitats as well. We must consider the species composition of all the landscape and evaluate the level of contrasts and mosaics in it. There are only a few good plant indicators (species or phytocoenoses), e. g. Peucedano – Asteretum sedifolii association never has been found in a primary alkali habitat (MOLNÁR ex verb., 2007). When grazing on primary alkali steppe is stopped, the absence of degradation or afforestation is typical, but there tends to be a higher litter production. Alkali habitats tolerate over-grazing well. MOLNÁR – BORHIDI (2003) add that a primary steppe could be changed to secondary steppe by a lower water level (drainage) and then Artemisio santonici – Festucetum pseudovinae changes into Achilleo setaceae – Festucetum pseudovinae SOÓ (1933) 1947 corr. BORHIDI 1996, and Camphorosmetum annuae RAPAICS ex SOÓ 1933 or Puccinellietum limosae MAGYAR ex SOÓ 1933 into Artemisio – Festucetum (the same process is going on in Slovakia, e. g. ELIÁŠ ex verb., 2007).

Typical of the steppe hallophytous associations is a "slushed" surface (MICHALKO et al. 1987). Creation of large "*szikpadka*s" (= szik threshhold, difficult to translate, in Hungarian padka = threshhold, process of their development: "*padkásodás*", MOLNÁR – BORHIDI 2003 write about it in Hungarian and describe it as microerosional mound or erosion slope) with a detailed micronisation typical of the Hungarian Great Plain (Nagyalföld) is in Slovakia a very rare phenomenon. After the visual observation of alkali habitats in Slovakia, the slushed surface was discovered within the less develo-

ped stages (Kamenín, Dérhídja-Veľké Kosihy), some of which originated from human management (probably several padkas in Iža and Pavol in Zlatná na Ostrove) or they are degraded (Sziky in Močonok) without Camphorosmetum plots in their lower parts. The fact that it is a matter of a world-wide spreading geomorphological process is also confirmed by our data from arid areas of the Atlas Mountains range, where this phenomenon has been found for instance near the salt lake Aguaman Sidi ben Ami (Morocco), also in the area of the upland platform "puno" in Peru and Bolivia or in the Ponto-Caspic region and Mongolia (personal observations of FEHÉR unpubl., 2003-2006). Less developed, small szikpadka can be developed in secondary alkali steppes as well (MOLNÁR 2003, MOLNÁR – BORHIDI 2003). KRIST (1940) wrote also that a small soil surface level difference (e. g. 20 cm or less) leads to a different vegetation type – a rich pattern mosaic, e. g. in Kamenín and Tvrdošovce (older szikpadka zonation studies: in Hungary e. g. RAPAICS 1926, 1927; in Serbia e. g. SLAVNIĆ 1939, BODROGKÖZY – GYÖRFFY 1970; in Slovakia and Bohemia e. g. VICEHEREK 1973).

But what is sure is that we cannot adopt all the quoted information without any criticism, since SW Slovakia especially can have different soil-climatic conditions, and it is less affected by continental and sub-Mediterranean climate compared to the Hungarian Great Plain (Nagyalföld). Differences that are not negligible can also be seen between the Hungarian Great Plain and the Hungarian-Austrian frontier alkali habitats near the Lake Neusiedel (Fertő-tó), for instance the occurrence of vicarizing *Puccinellia peisonis* in the west. From the class of continental halophytic associations of Puccinellio – Salicornietea TOPA 1939 even one whole important Pannonian endemic order, Peucedano officinalis – Asterion sedifolii BORHIDI 1996 with a doubtful origin, seemed to be missing in Slovakia. It is a tall-herb phytocoenosis with a forest-steppe and fringe character, rich in dicotyledonous species with dominant key-stone taxa *Peucedanum officinale* and *Galatella punctata* (see above). By the way it is also rare in Hungary (c.f. VARGA – VARGÁNÉ SIPOS 1999), although the dominant *Galatella punctata* grows in our country very rarely (GRULICH – FERÁKOVÁ 1999, SÁDOVSKÝ 2004). The Slovakian populations of *G. punctata* grow in the non-halophytic alliances of Alopecurion pratensis PASSARGE 1964 and Arrhenatherion W. KOCH 1926 (SÁDOVSKÝ 2004). *Peucedanum officinale* is also included in the checklist of Slovak flora (MARHOLD, HINDÁK 1998) and its distribution in Flora of Slovakia (HLAVAČEK et al. 1984). We think that the actual occurrence of this species needs a review. Nor did VICHEREK (1973) mention Peucedano – Asterion (or a similar association) in his basic halophytic vegetation study for (Czecho)Slovakia. According to a visual observation the locality in Kamenín might be dominated by Peucedano –Asteretum without *Peucedanum officinale* (MOLNÁR ex verb., 2007, it needs a detailed study).

The alkali habitats of Slovakia had a relatively high biodiversity, which was well preserved in some localities. It is evidenced by a recent list of rare plant species in comparison with older data from the sites of Hájske, Horná Kráľová and Močenok (MATUŠICOVÁ – ČERNUŠÁKOVÁ 2005). Some halophytes have moved into village/urban areas (c.f. SVOBODOVÁ 1986). Unlike Central European alkali habitats, there are sometimes monodominats (even one species stands) on salty neopedons near the Mediterranean Sea (apparently as the initiation phase of succession, e. g. in Albania to the north of the town of Durrës/Durazzo, FEHÉR unpubl., 2004).

Long-time survival of fragmentary but valuable alkali habitats in Slovakia is questionable. Various types of salt fields in the selected territory can be endangered by various effects, e. g. ending of pasture endangers some types of hallophytous associations and drainage also degrades these associations [except for Agrostio – Alopecuretum pratensis SOÓ (1933) 1947] where some unwanted succession changes have been found.

Conclusions

Paleo-pedological and archeobotanical knowledge offer only a negligible quantity of valuable data for the reconstruction of the origins of alkali habitats and their development in the south-west of Slovakia. Medieval works also contain minimal information about possible alkali vegetation which was probably spread only locally within the forest vegetation. Later as a consequence of hydro-ameliorative intervention into the landscape and intense pasture especially by sheep, sziks *could* enlarge their area. Their largest area was attained, it is *assumed*, in the 19th century as evidenced by map and property listings from those times. In the 20th century salt marshes and steppes (especially in the mid 20th century) were mostly recultivated and their condition got worse to a such degree that today we only know their various valuable fragments.

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