Inventory of aquatic plants in the Danube Delta: a pilot study in Romania

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With 5 figures and 1 table

Abstract: The Danube Delta is one of the largest delta areas of the world and its water bodies belong to many different types, ranging from fast flowing large channels to still oxbow and flood plain lakes. The Tulcea arm, Sf. Gheorghe arm, Sulina arm, Litcov channel, the Old Danube, and the Magearu channel were chosen as study reaches where survey units were placed. 36 species were found to be closely associated with the water bodies and their littoral reaches.

The highest number of species was found in the Magearu channel, whereas in the large channels used for large ship navigation only a few species were detected. The highest plant mass was also detected in channels with predominately lentic conditions, and in channels with considerable water flow the plant mass was low. Some channels like Litcov were dominated by amphibious species such as *Mentha aquatica* in the Old Danube *Ceratophyllum demersum* was ubiquitous, but it was rather unexpected to find *Salvinia natans* and *Lemna minor* as the most frequent species in the structured littoral of the large navigable channels. The original findings indicate that too little is still known of the abundance and distribution pattern of aquatic plants in the water bodies of the Danube Delta.

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Introduction

The Danube Delta belongs to the Lower Danube River System (LDRS), which extends for 1080 km within Romania. It receives water from the lower drainage basin (218660 km^2), 75% of which covers 90% of the Romanian surface (Vadineanu et al., 1998). The LDRS includes: 1 – Iron Gate reservoirs, 2 – upper floodplain between Calafat and Calarasi, 3 – central floodplain between Calarasi and Braila, 4 – lower floodplain between Braila and Tulcea, 5 – the real delta between the branches of the Danube, 6 – the Dranow floodplain, 7 – a large complex of lagoon lakes, 8 – secondary Chilia delta, 9 – the Black Sea littoral waters. The LDRS surface area includes agricultural land (mainly within the upstream floodplain units), the aquatic environment (delta and lagoon system) and the wetlands (downstream floodplain). In this frame the Danube Delta is still one of the most (semi-) natural areas in the LDRS and has outstanding ecological value. It is a heterogeneous and dynamic complex of ecosystems of various type (channels, lakes, reed wetlands, sand dunes, oak, willow and poplar forests, pasture, shallow water, etc.), covering 3 446 km^2 in Romania.

The delta is relatively flat, with an inclination of 0,006 ‰, and 70-80 % of the area is permanently or temporarily covered by water (Laslöffy 1967). The delta is shaped like an equilateral triangle with sides some 80 km long. The Danube carries an average of 50 million tons of suspended solids annually (about eight times more than the Tiber, 30 times more than the Rhine). The water temperature varies between 20^0 C in June, 22^0 C in August and 18^0 C in September.

The hydrographic network of the Danube Delta includes two components: 1 - the main water courses represented by Danube arms (Chilia, Tulcea, Sulina, Sf. Gheorghe) through which the river flows into the sea, 2 - the secondary water units represented by creeks (former arms of the Danube, some of which are blocked by silty vegetation), backwaters (smaller creeks), channels (rectified and dredged) and periboinas (littoral loopholes where water is exchanged). Beside these are there other wetland and lacustrine habitats in depression in the floodplain: marshes (0.5 – 0.3 m deep), estuaries (by the mouth of rivulets), lagoons (old marine gulfs), swamps (low water that may not be permanent) and "japsas" (pools left after floods) as well as lakes.

The aquatic vegetation is of many distinct types, and it varies according to water types (Danube tributaries, channels, fresh and salt water lakes, ponds; Ciocârlan 1994, Hanganu et al. 1995). The aquatic vegetation is exceptionally rich in lakes, creeks, and channels but it is also well represented along the Danube arms (SÂRBU et al. 1999). Macrophytes are important and very sensitive primary producers, which respond to eutrophication processes and consequently affect the structure and functions of the aquatic systems of the LDRS (SÂRBU et al. 1997). Forests occur in a relatively small portion of the Delta, covering approximately 5% of its total surface. These can be divided into two different types: forests in the fluvial zone and forests in the marine zone of the Delta. A unique structure is represented by the so-called “plaur formations” (reed islands and floating vegetation). When water levels are unusually low, a part of the plaur dries out in the same way as other formations on the water body edges. They become more or less terrestrial in association with non-floating *Phragmites*.

Reedbeds are a characteristic feature of the Danube Delta landscape. Covering vast areas, they represent the largest closed unit of reeds in Europe. Many other aquatic plants are also present.

Traditional land use in the Delta includes fishing, hunting, extensive cattle and pig breeding, cultivation of some agricultural and horticultural crops, honey production, hay cutting and collection of materials such as woods and reed (SCHNEIDER 1996).

Study site

In order to cover some of the heterogeneity of the Danube Delta hydrographic network, seven research areas located along the river arms (Tulcea, Sf. Gheorghe, Sulina) as well as along some important channels (Litcov, Papadia Noua, Old Danube, Magearu) were selected and assessed.

Tulcea arm is a main shipping channel, with no floodplain, and surrounded by agricultural areas and willow plantations. The bank structure and bed sediment consists of fine inorganic material. The current velocity was assessed as medium (0,35 – 0,65 $m..s^{-1}$) and the Secchi transparency was low (0.4 m). It is a short arm running between the Chilia arm and the origin of the Sf. Gheorghe arm, near Tulcea town. Its length is 19 km. It has a maximum width of 300 m and a maximum depth of 34 m. Its sinuosity coefficient is 1.4 and it carries about 40% of the Danube flow. Two survey units of 1800 m length, located on the left bank (miles 35 and 34), were assessed.

Sf. Gheorghe arm is the oldest arm through which the Danube flows into the sea. It is 109 km in length, with a maximum width of 550 m, maximum depth of 26 m, and sinuosity coefficient of 1.6. It carries about 22% of the river water and is used for local shipping. It is an arm without a floodplain, surrounded mostly by willow plantations and some villages and pastures. The bank structure and the sediment type is mainly sand. The current velocity was evaluated as medium, Secchi transparency was 0.5–0.6 m. Along this arm 13 survey units of 1000 m length, located on the left and right side, were assessed.

Sulina arm is the most modified arm of the Danube. It is dredged and used as a maritime traffic channel. It is 64 km in length with a maximum width of 250 m, maximum depth of 18 m, and a sinuosity coefficient is 1.3. This channel carries about 18% of the river water. The left side of the arm lacks a floodplain, is surrounded by pastures or alluvial wet broad leafed forests. The right side includes oxbows with permanent vegetation, surrounded by alluvial wet broad leafed forests. These are separated from the main channel of the Sulina arm except during periods of high floods. The bank structure is stones for the main channel and fine inorganic material for the oxbow areas. The sediment is comoposed of fine inorganic material. The current velocity was evaluated as slow and Secchi transparency was low (0.3 m) to medium (0..5 m). Along this arm six survey units (four on the left side and two on the right side) of 1800 m total length, were considered between miles 33 and 30.

Litcov channel is a big secondary channel of the Sf. Gheorghe arm, with a length of 4 km surrounded, by willow alluvial forests. The banks and bed are composed of fine inorganic material. The water flow was evaluated as low and Secchi transparency was high (1.1 m). One survey unit of 4000 m length was assessed on both banks.

Papadia Noua channel is located on the eastern part of the delta and is connected to the Old Danube channel. Both banks it is surrounded by alluvial willow forests and humid meadows. Bed and banks consist of fine inorganic material. Current velocity was slow and Secchi transparency was high (0.7–1.0 m). Five survey units of 1,000 m length each, located on the left and right bank, were assessed.

Old Danube is a big secondary channel, leading back to the Sulina arm of the Danube River. The surrounding land is covered by natural reed and alluvial forests dominated by *Salix* sp. The banks have a fine inorganic substrate and the sediment is composed of detritus and other organic material. Water flow is low and Secchi transparency is high (1.5–2.0 m). Along this channel nine survey units of 1000 m length, on the left and right bank, were assessed.

Magearu channel is a small channel originating from the big secondary Old Danube channel, that is connected to some lakes. The channel is surrounded by natural reed. Its bank structure consists of floating mats (plaur) and the sediment is represented by detritus and other organic material. Water flow is low and Secchi transparency is high (2.5 m). One survey unit of 5000 m length (left and right bank) was assessed.

Methods

The aquatic macrophytes were surveyed in September 1999 in 37 survey units distributed in the Danube Delta as follows: two units, 1800 m length, located on the left side of the Tulcea arm (miles 35 and 34); 13 units, 1000 m length, located on the left and right side of the Sf. Gheorghe arm (river km 104–99); six units, 1800 m length, located on the left and right side of the Sulina arm (between miles 33 and 30); one survey unit, 4000 m length, assessed on both banks on the Litcov channel (river km 101–95); five units, 1000 m length, both banks, on the Papadia Noua channel; nine survey units, 1000 m length, both banks, located on the Old Danube channel; one survey unit, 5000 m length, depending on the Magearu channel. The accumulated length of the studied area was 50.4 km. The studied survey units varied between 1000 m and 5000 m length in accordance with the ecological uniformity. The majority of survey units ranged from 1000 to 1800 m. The nomenclature of taxa follows Flora RSR (SAVULESCU 1952–1976).

In each survey unit the Plant Mass Estimate (PME, KOHLER et al. 1971) was assessed on a five level scale (1 – rare, 2 – occasional, 3 – frequent, 4 – abundant, 5 – very abundant).

The first item of the methodology is a complete species list, including authorities for species name, species name abbreviation and growth form category (defined by the Expert Group Macrophytes of the International Association for the Danube Research – I.A.D.). The second item is represented by the Distribution Diagram, which depicts the amount of each species in each survey stretch in the studied river areas. The Distribution Diagram data form the basis for the numerical derivative: Relative Plant Mass (RPM), Mean Mass Indices (MMO, MMT) and Distribution Ratio ("d") which can be use for describing quantitative relationships of aquatic macrophytes in rivers and still waters. More details on the field data assessment and the numerical and graphic data presentation is given in the "Methods" chapter in this volume.

Results

Species List

35 species of macrophytes were found in the selected survey units of the Danube arms and channels. In general all these species were common in both branches and side channels of the Danube River. They were also found frequently in floodplain water bodies or in lakes and oxbows (Table 1). The hydrophytes were represented by 28 species and the helophytes

by seven species. Some species like *Sagittaria sagittifolia* were found growing both as a hydrophyte, and as a helophyte.

Distribution Diagram

The Distribution Diagram (Figure 1) shows the length of each survey stretch proportional to the length of the studied river reach and the balance between the macrophyte species. Diversity and distribution of macrophytes are higher in the channel stretches than in the main arms of the river.

Relative Plant Mass

Relative Plant Mass for individual species is presented in Figure 2 for individual species. Hydrophytes are dominated by *Ceratophyllum demersum*, *Salvinia natans* and *Lemna minor*, and helophytes by *Mentha aquatica*.

Mean Mass Index and Distribution Ratio

In the Danube arms (small flood plain canals: Litcov and Papadia Noua, big navigation canals: Tulcea, Sulina, Sf. Gheorghe, Figures 3 & 5) the MMO values are below (3), which means that the levels “rare” (1) and “occasional” (2) are found in a great many cases, but the Distribution Ratio “d” was in many cases higher than 0.5. For the Old Danube and Magearu channels (Figure 4) the MMO was higher than (3) only for *Ceratophyllum demersum* and *Salvinia natans*, but the Distribution Ratio was frequently higher than 0.5.

Discussion

Macrophyte survey in the Danube Delta is not a very process as it has to take into consideration the dimension of the area and the heterogeneity of the ecological systems. With this fact in mind this pilot study can get only some preliminary information about the richness and distribution of the macrophytes. It represents also a first test of the Kohler methodology to assess the aquatic macrophyte vegetation of the Danube Delta.

The presence of levees along the main river branches, the sediment type, the low water transparency and also the water flow reduced the diversity of the rhizophytes and helophytes species and gave advantage to pleustophytes. Floating species such as *Lemna gibba*, *L. trisulca*, *L. minor, Salvina natans,* and *Spirodela polyrhiza* developed where low current velocities occurred (Figure 1). *Ceratophyllum demersum* is normally not known of growing both in locations with moderate flow, but was found in river arms and in side channels.

The species richness increases from the Danube arms (maximum: 11 species) to the Delta channels (maximum: 28 species). The helophytes are well represented in the channels surrounded by alluvial forest, dominated by *Salix sp*. (Old Danube) or by natural reed (Magearu). In that area the whole range of the identified helophyte species were present. This was also the case for the hydrophytes, both pleustophytes and rhizophytes. In the channels species such as *Ceratophyllum demersum*, *Hydrocharis morsus-ranae*, *Nuphar luteua*, *Potamogeton pectinatus*, *Salvinia natans*, *Lemna minor* were the dominating macrophyte primary producers. With regard to the whole study area, *Ceratophyllum demersum*, *Salvinia natans* and *Lemna minor* were the dominant hydrophytes and *Mentha aquatica* the dominant helophyte.

Conclusion

The characteristics of the running water courses (main arms of the river and channels of different size) in the Danube Delta are well reflected in the composition and distribution of the macrophyte vegetation. Most of the species found are ubiquitous to the hydrological network of water corridors which cross the Danube Delta, but some of them are more sensitive to the water flow and sediment type (rhizophytes) than others (pleustophytes).

The diking activity reduced drastically the diversity of aquatic macrophytes diversity both hydrophytes and helophytes on the Danube arms, associated with significant changes in the aquatic primary producers compartment. Only pleustophytes species dominate in these waters.

The open channels connected to the main arms of the river exhibit a much higher aquatic macrophyte diversity. However, under the trophic conditions present there, nutrient-tolerant species such as *Ceratophyllum demersum*, *Potamogeton pectinatus*, *Salvinia natans*, *Lemna minor* are favoured. This invasive behaviour seems to be a reaction to the energy flow which is correlated with the general eutrophication of aquatic systems in the Danube Delta.

The dynamics and succession of the aquatic macrophyte communities represent important indicators of the ecological quality, which is influenced by hydromorphological modifications and nutrient level. Regarding this the highly efficient survey method used here is of great importance, as it enables researchers to produce full inventories of taxa and to monitor efficiently any relevant changes in the aquatic vegetation. With little investment of time this method offers significant information, relating the structure of the macrophyte communities (expressed in terms of species number and distribution) to spatial heterogeneity, water flow, sediment type, light regime and other important habitat parameters.

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Figure Captions:

Fig. 1. The Distribution Diagram

Fig. 2. Relative Plant Mass of aquatic plants in the Danube arms and channels

Fig. 3. Mean Mass Index of aquatic plants in Litcov and Papadia Noua channels and Distribution Ratios

Fig. 4. Mean Mass Index of aquatic plants in Old Danube and Magearu channels and Distribution Ratios

Fig. 5. Mean Mass Index of aquatic plants in the Danube arms (Tulcea, Sulina and Sf. Gheorghe) and Distribution Ratios

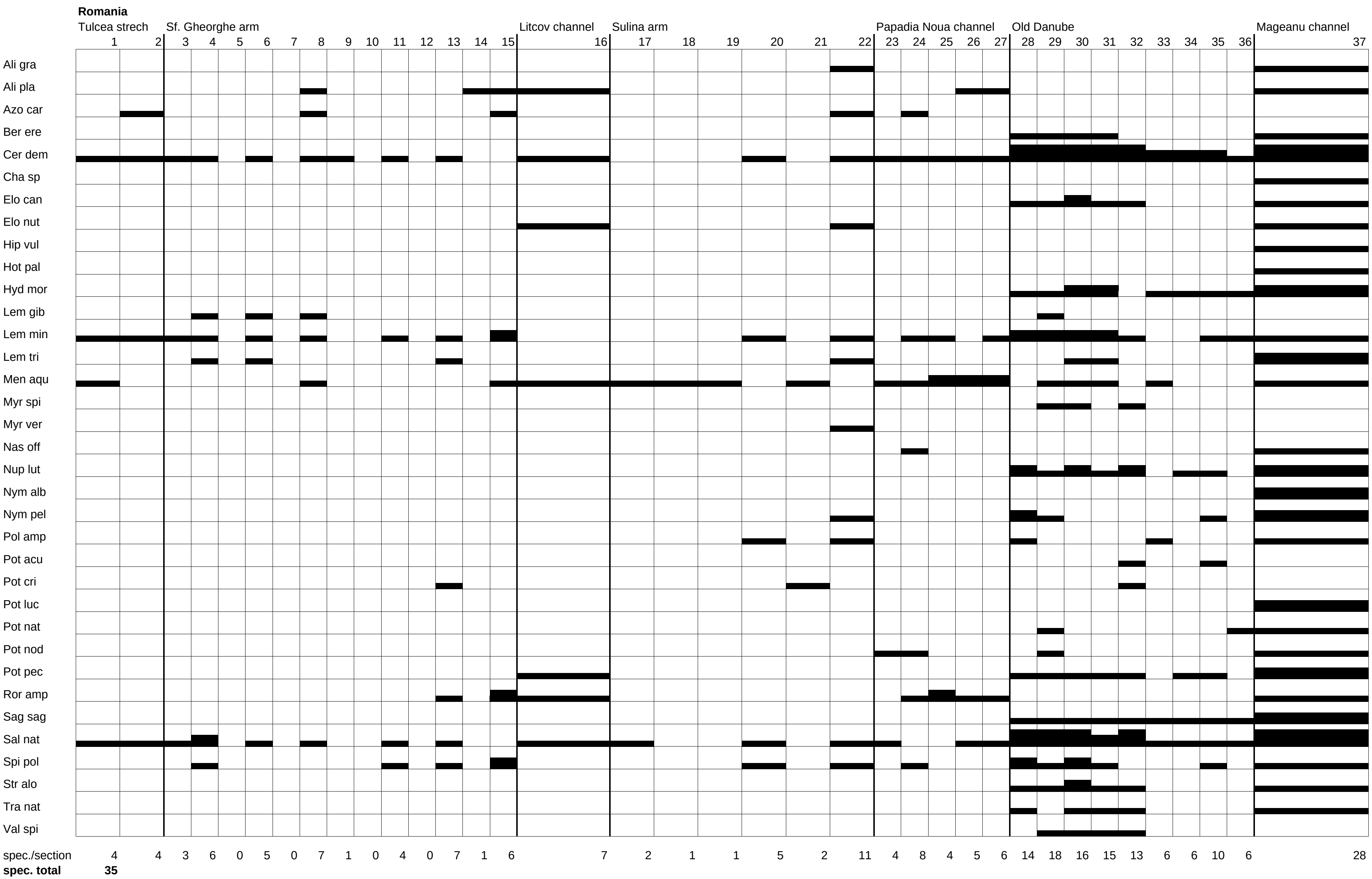
Tables:

Table 1: Species list (37 stretches in the Danube Delta)

Species	Abbrev.	Growth form
Hydrophytes		
Azolla carolliniana Willd.	Azo car	ap
Ceratophyllum demersum L.	Cer dem	sp
Chara sp.	Cha sp	sa
*Elodea cana*densis Michx.	Elo can	sa
Elodea nuttallii (Planchon) St. John	Elo nut	sa
Hippuris vulgaris L.	Hip vul	sa
Hottonia palustris L.	Hot pal	sa
Hydrocharis morsus-ranae L.	Hyd mor	ap
Lemna gibba L.	Lem gib	ap
Lemna minor L.	Lem min	ap
Lemna trisulca L.	Lem tri	sp
Myriophyllum spicatum L.	Myr spi	sa
Myriophyllum verticillatum L.	Myr ver	sa
Nuphar luteum (L.) Sibth. & Sm.	Nup lut	fl
Nymphaea alba L.	Nym alb	fl
Nymphoides peltata (S. G. Gmelin) O. Kuntze	Nym pel	fl
Potamogeton acutifolius Link in Romer et Schultes	Pot acu	sa
Potamogeton crispus L.	Pot cri	sa
Potamogeton lucens L.	Pot luc	sa
Potamogeton natans L.	Pot nat	fl
Potamogeton nodosus Poiret in Lam.	Pot nod	fl
Potamogeton pectinatus L.	Pot pec	sa
Sagittaria sagittifolia L.	Sag sag	sa
Salvinia natans (L.) All.	Sal nat	ap
Spirodela polyrhiza (L.) Schleiden	Spi pol	ap
Stratiotes aloides L.	Str alo	sa
Trapa natans L.	Tra nat	sa
Vallisneria spiralis L.	Val spi	sa
Helophytes		
Alisma plantago-aquatica L.	Ali pla	he
Alisma gramineum Lej/Gmel	Ali gra	he
Berula erecta (Hudson) Coville	Ber ere	he
Mentha aquatica L.	Men aqu	he
Nasturtium officinale R. Brown	Nas off	he
Polygonum amphibium L.	Pol amp	he
Rorippa amphibia (L.) Besser	Ror amp	he
Sagittaria sagittifolia L.	Sag sag	he

sa = submerged anchored hydrophytes, ap = acro-pleustophyte, sp = submerged pleustrophyte, fl = floating leaf form, he = helophyte

Fig. 1


Romania
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Litcov channel
Sulina arm
Papadia Noua channel
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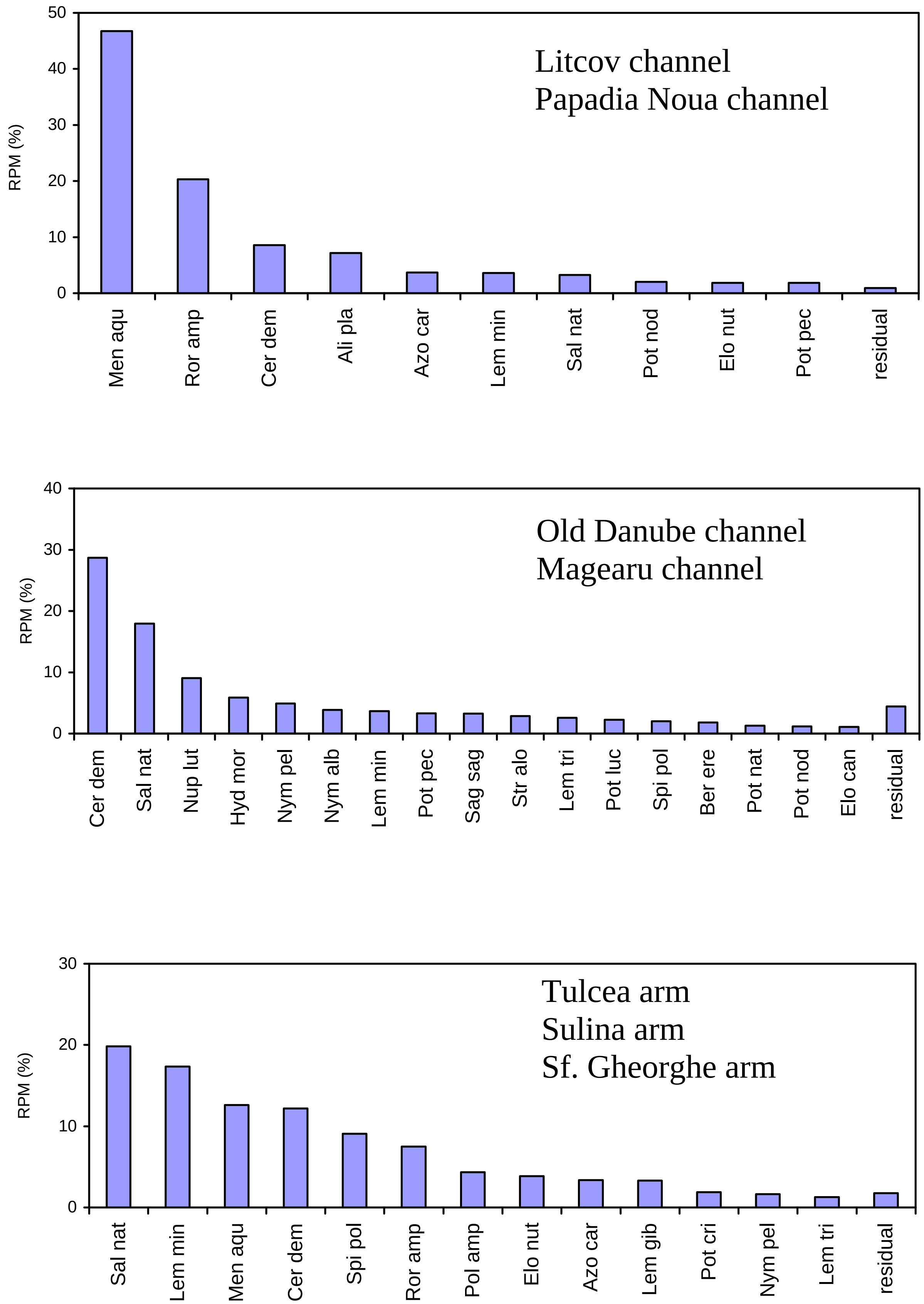
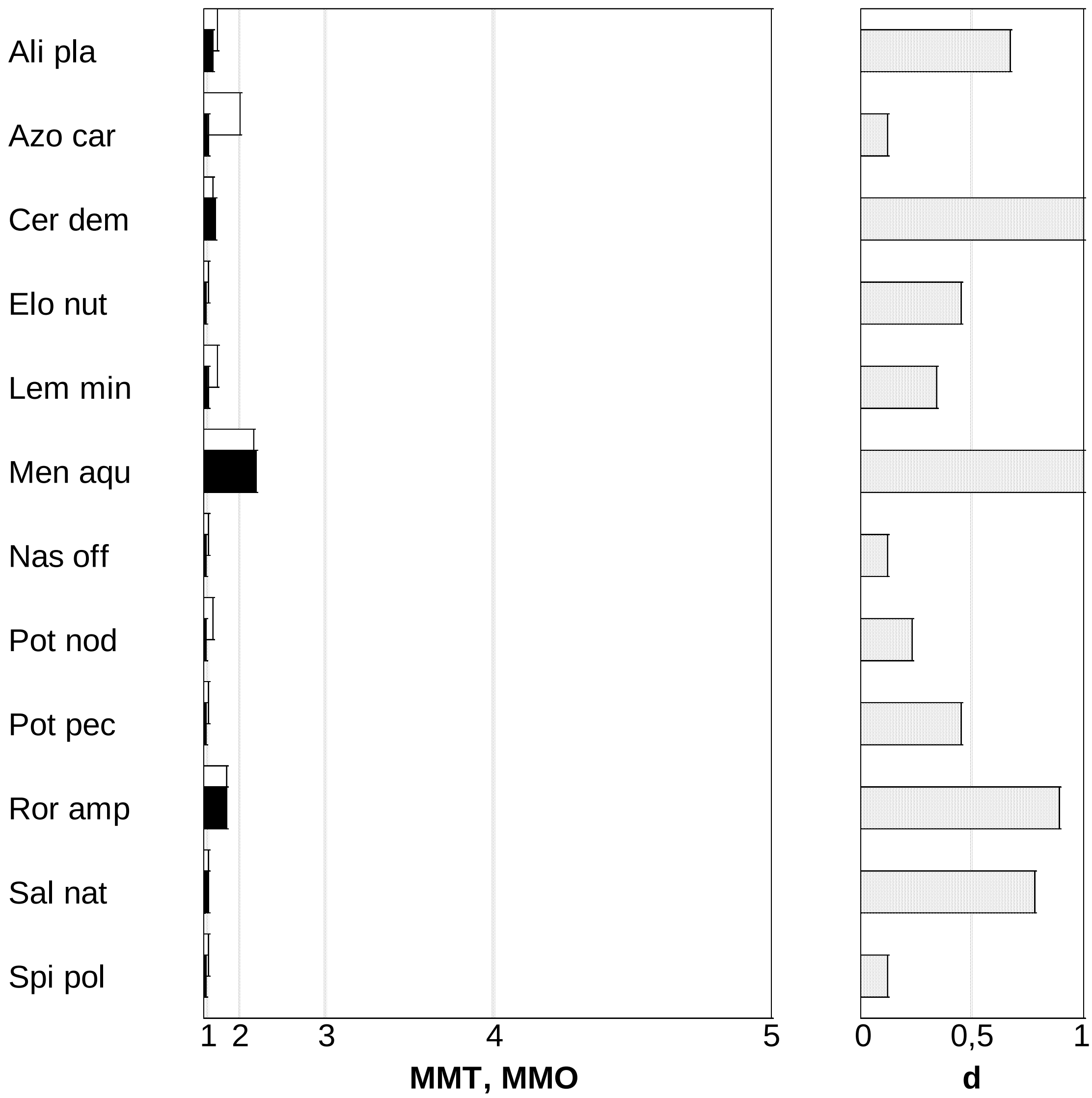


Fig. 2. Relative Plant Mass of aquatic plants in the Danube arms and channels

Fig 3a und 3b: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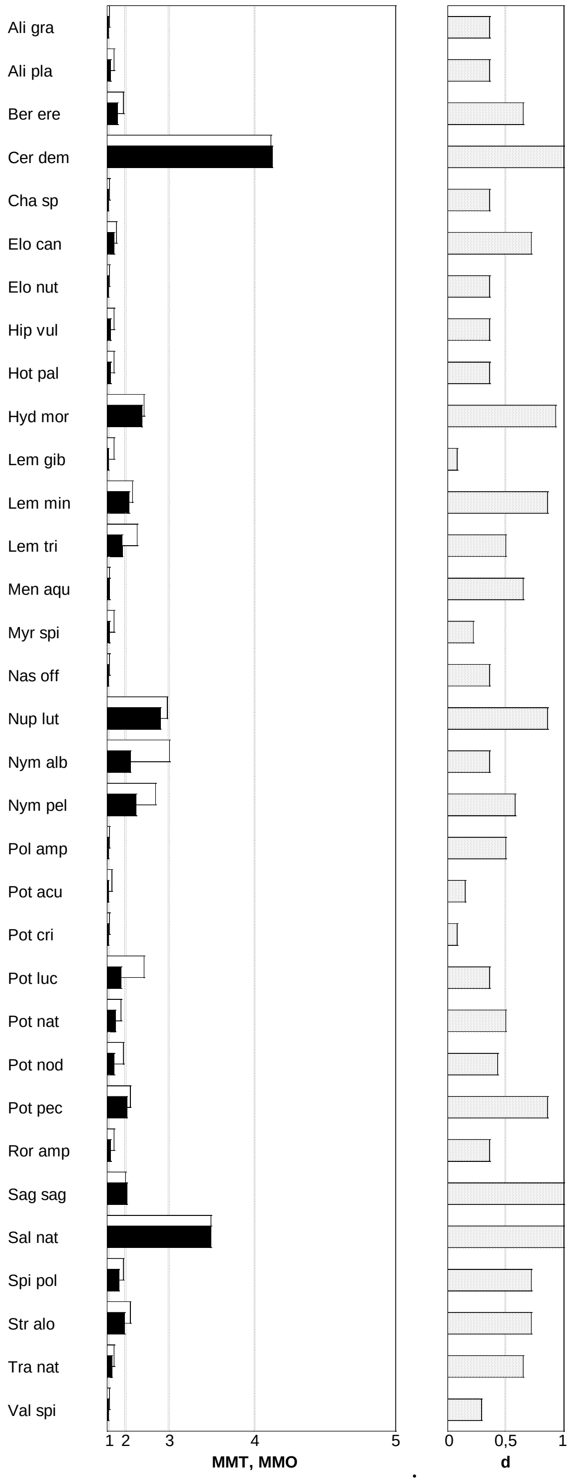

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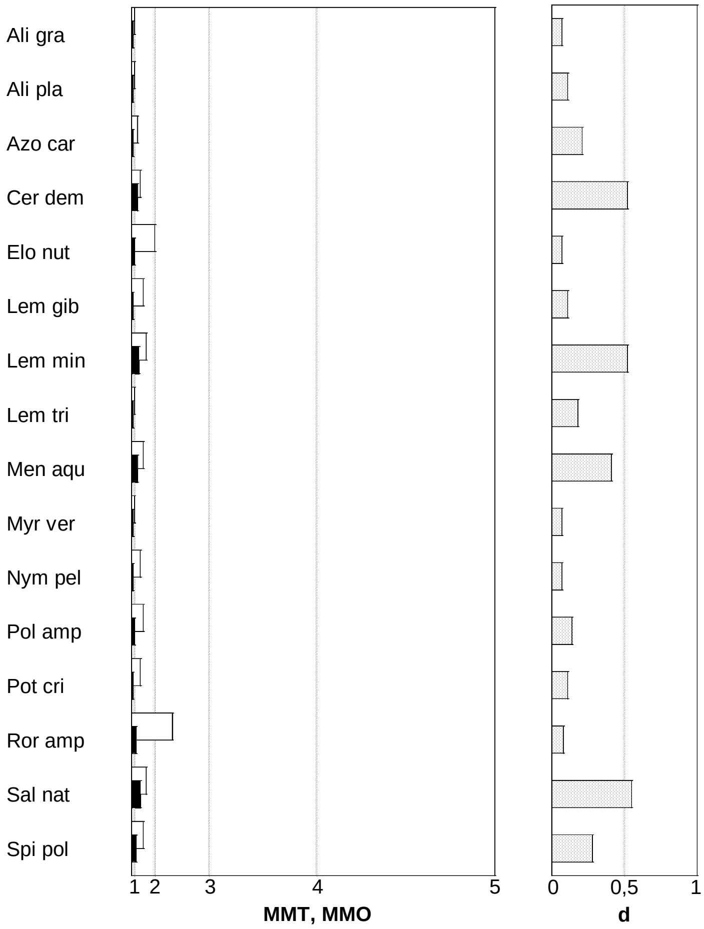
Fig 5a und 5b: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