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DISTRIBUTION PATTERNS OF AQUATIC AND RIPARIAN IN ERRA RIVER, CENTRAL PORTUGAL

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RESUM

S'estudien els patrons de distribució de la vegetació aquàtica i ripària del sistema del riu Erra, una conca hidrogràfica de 35 Km de llargària. La densitat, la coberta vegetal i la localització de les plantes foren monitoritzades durant l'estació de creixement (1988) dins transectes de 150 m de longitud separats per 3 Km. El riu Erra és un tributari del sistema Tagus. La conca consta principalment de sorrenques toves i sediments també sorrencs, predominantment acídics. L'aigua mostra una baixa alcalinitat, pH i conductivitat. Les capçaleres del riu estan conreuades, però als trams mitjà i baix les valls són estretes i presenten un patró irregular d'abandonament i restabliment. S'han tipificat deu perfils de riu, anomenats canals de la capçalera del riu, tres formacions pantanoses, i zones del curs baix del riu sorrenques o bé densament poblades de vegetació. Es discuteix la vegetació associada. S'ha utilitzat l'anàlisi multivariable per tal de clarificar els patrons de distribució vegetal, i s'han constatat cinc grups amb espècies característiques, relacionades amb l'ús de la terra per l'agricultura.

ABSTRACT

The ecology and distribution patterns of aquatic and riparian vegetation of Erra river system were studied, an hydrografic bassin 35 km long. Density, cover and plant location were recorded during growth season (1988) on 150 m long stretches disting 3 km.
The Erra river is a lowland tributary of Tagus system. The bassin consists mainly of soft sandstone ans sandy sediments, predominantly acidic. The water shows low alkalinity, pH and conductivity. River heads are agricultured, but in middle and downstream areas the valleys are narrow and have an irregular pattern of abandonment and re-establishment. Ten river profiles were tipified, namely head river channels, three swamp formations and sandy open or densely forested downstreams. The associated vegetation is discussed. Multivariate analysis was used to clarify plant distributional patterns, resulting in five grouping tendencies with characteristics species, connected with agricultural land use.

Key words: macrophytes, distribution patterns, typology, riparian formations, river ecology.

INTRODUCTION

Studies of aquatic and riparian formations are still scarse among portuguese hydrobiological publications. Only recently some studies connected with reservoir establishment (Lousã and Rosario, 1986), riparian woody communities (Ferreira and Lousã, 1986;1988) or river and pound surveys (Ferreira and Monteiro, 1987; 1988; Lousã, 1980) have focused their attention on macrophyte ecology.

The river Sorraia, the largest southern tributary of Tagus system, is a wide hydrographic bassin where agricultural and forestry activities cause the main stress on river communities, namely river bed disturbance, riparian tree cutting, eutrophication and chemical pollution. Since 1986, the Forestry and the Botany Departments of the Agronomy Institute of Lisboa have been studying this area, aiming to understand vegetation patterns and seasonal evolution as well as to assess agricultural impacts by means of plant surveys and the associated water and substracte characterization (Ferreira & Moreira, 1988). Also, aquatic weed bioecology and control represent an important line of research (Moreira et al., 1987). This work is a contribution to the global project.

METHODS

The survey of aquatic riparian vegetation of the river network was performed between April and July 1988. A total of fifteen 100 m long stretches were surveyed, and the species list, along with density (1-5 scale), and ecological enplacement (bank, sand flats, water) were recorded. Sites disted no more than 3 Km. Cross-profiles of river bed were also studied. The transversal lenght of the inventaries was determined by the end of the hygrophitic vegetation, that is, the top of the highest bank. Conductivity and pH were measured on side with a YSI58 and a WTW90, respectively. Alkalinity was determined by volumetry with 0.01N sulphuric acid. Dominant substractes were assessed visually.

Lifeforms were obtained from Franco (1971;1984), Vasconcelos (1970) Valdes et al. (1987) and personal observations. Cros-profiles of the river were visually analized through their schematic representation on scale. Later on, the inventaries were treated by factorial correspondance analysis (Benzecri et al., 1973) using a S.P.A.D. stadistical package (Lebart et al., 1985).

RESULTS

The river Erra is a small tributary of the Sorraia, with a total lenght of around 35 Km. The decrease in altitude over this distance is 130 m. Soft sandstone and clay of miocenic and pliocenic origin dominate and the soil is predominantly acidic (4.6 to 5.6). Heterogenous holocenic sediments and sandy plistocenic sediments occupy the lower parts of the river valleys.

Most areas of agricultural land use (68% total against 59% in 1969) are instaled upstream because the heads of the river have relatively wide and flat valleys. Rice, tomato and mais are the main cultures. There is a tendency to increase agricultured areas, especially after two small irrigation reservoir were built in 1984.

Conductivity ranged from 60 to 120 micromhos. cm^{-1}, and is generally low, as well as pH (6.5 to 7.2 in the main river but as 5.1 in near-by swamps) and alkalinity (3 to 12 mg $CaCO_3$. l^{-1}) This rough chemical information results from irregular record during surveys, and a monthly sampling which started in October 88. The predominant substracte is sand and gravel, except in agricultured influenced upstream and in swamps contiguous to the river, where a muddy substrate predominantes.

Figure 1 presents the cross-profils of the river sites surveyed and Table 1 shows the lifeforms found and species richness per inventary. A general grouping can be discussed as follows:

1. The sites in which riparian trees are prevailing and woody species are numerous (A8 and A9). In A8 the open space is mainly occupied by annuals.

Table 1. Comparisons of lifeforms (as % of species in each category).

Sites	AQ	AN	PE	WO	species richness
Average %	28	30	15	27	
C1				-	38
C2		+		-	54
C3	-	++		-	68
B1	-		++		41
B2	+++	--			43
A1		+	-		36
A2	-	-		+	47
A3	+++	---			38
A4	+	--	+	-	54
A5	++	-			56
A6	-	+			56
A7			-		77
A8	--	++	--	-	50
A9	---		-	+++	33
A0	-	++		-	73

-/+ = 5-10% less/more than the average % of all samples
--/++ = 10-15% less/more than the average % of all samples
---/+++ = > 15% less/more than the average % of all samples
AN- (bi) annuals; PE- small perennial species (hemicryptophytes, geophytes and nano-chamaephytes); WO- woody species (chamaephytes and phanerophytes); AQ- aquatic plants (hydrophytes and obligate/facultative helophytes)

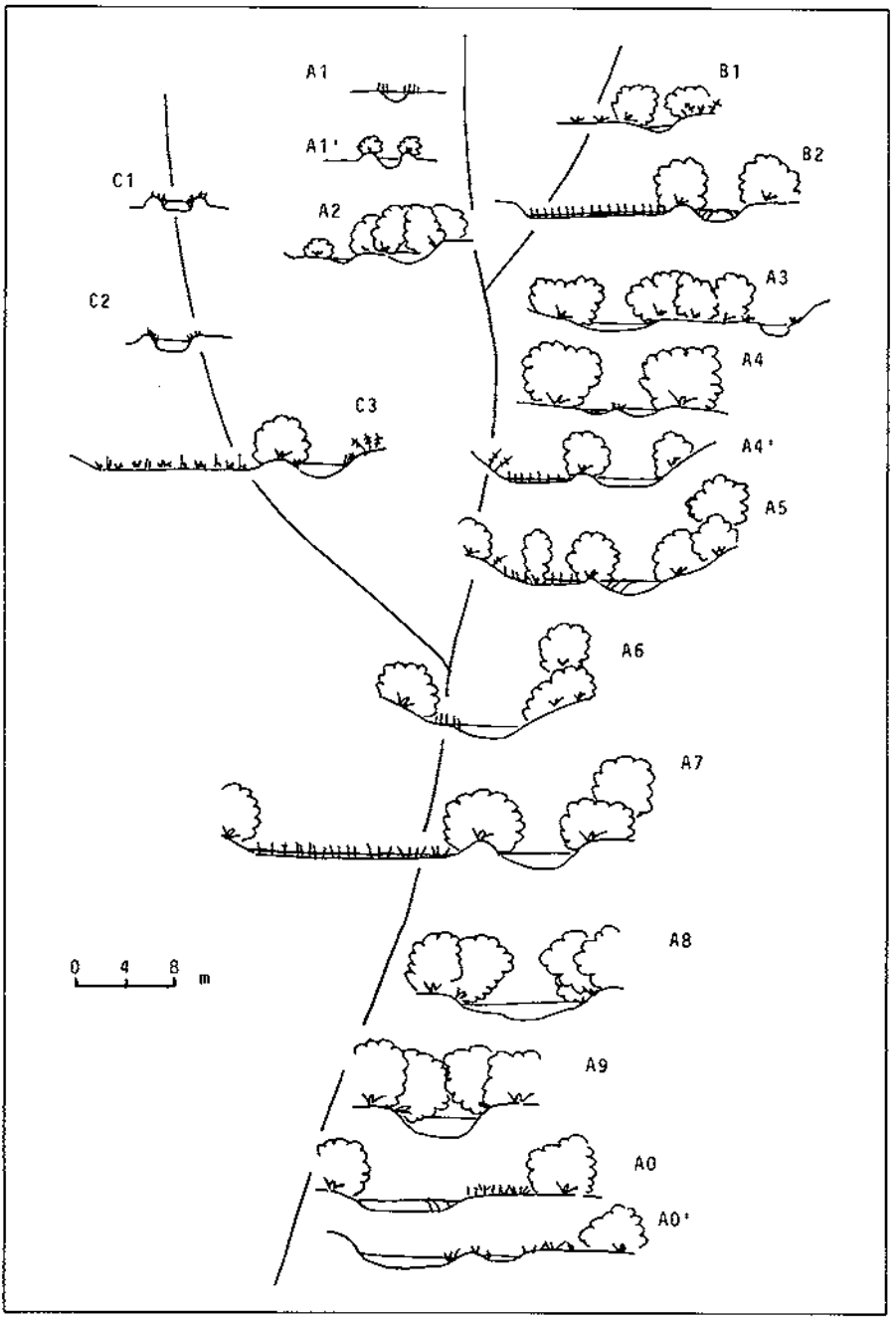

Figure 1. Schematic representation on scale of the cross-profiles found for each studied site.

2. Sites that are surrounded by agricultural land (C1, C2, B1, A1 and A2). In A2 and B2 the river bed is shaded by small trees, nevertheless, there are few woody species. C1, C2 and A2 are completely open; A1 and C2 are relatively rich in annuals whereas perennials are predominant in C1.

3. Sites with extended marshes (C3,B2,A3,A4,A5 and A7). C3 is strikingly rich in annuals. B2, A3, A4 and A5 are relatively rich in helophytes and hydrophytes and poor in annuals. A7 appears to have a transitional position between groups 1 and 4, and all lifeforms are well presented.

4. Sites A6 and A0, that are half open, relatively rich in annuals species and poor in helophytes and hydrophytes.

The species richness ranged from 26 (A1) to 77(A7) per site. The highest number are coincident with the highest numbers of annuals species, especially in A0 and C3. The open agricultural heads and tree dominated sites appeared to be poorest in species.

The species and surveyed stes are represented in a two dimensional disposition by means of a factorial correspondence analysis (Fig.2). The first two axis account for 30% of the variation present. Only species found in more than 2/3 of surveys are represented. the analysis of Fig. 1 and 2 allow us to discuss further grouping as follows:

I. A group including C1, C2, B1, A1 and A2: heads/agriculture

No species is obviously associated to this group, assuming a more-than-one-site occurence indication.

II. A group including B2, A3, A4 and A5: marshes/middlestream

Although widespread, the following species have their main occurence here: *Ludwigia palustris, Baldellia ranunculoides, Lythrum junceum* and *Mentha aquatica*. Exclusive marsh species are: *Hypericum elodes, Anagallis tenella, Hydrocotyle vulgaris, Juncus bulbosus, Juncus pygmaeus, J. subnodulosus, J. tenageia, Leontodon toroxacoides, Peucedanum lancifolium, Scirpus cernuus* and *Scutellaria minor.*

III. A group including A6, A8, A9 and A0: downstream

Two different subtypes can be distinguished. One of dense tree ocupation, favouring species like *Osmunda regalis, Crataegus monogyna, Frangula alnus, Geranium purpureum, Hedera helix, Ruscus aculeatus, Smilax aspera.* And another with wide open areas (sand flats), where species like *Spergularia purpurea, Chrysanthemum coronarum, Cyperus eragrostis, Plantago lagopus, Silene gallica* and *Spergula arvensis* seem to occur preferably.

Some sites are transitional representatives, like C3 between heads/agriculture and marshes/middlestream, and A6, between this last one and downstreamm reaches. A7 is an outstanding inventary; apart from the marsh-species, the presence of several tree species and annuals give rise to a relationship with tho other downstream sites. Besides the already pointed marsh species, some more occur here: *Carex laevigata, Eleocharis multicaulis, Fuirena pubescens, Galium helodes, Ranunculus flammula* and *Silene laeta.*

The most common and widespread species in the Erra are (divided in

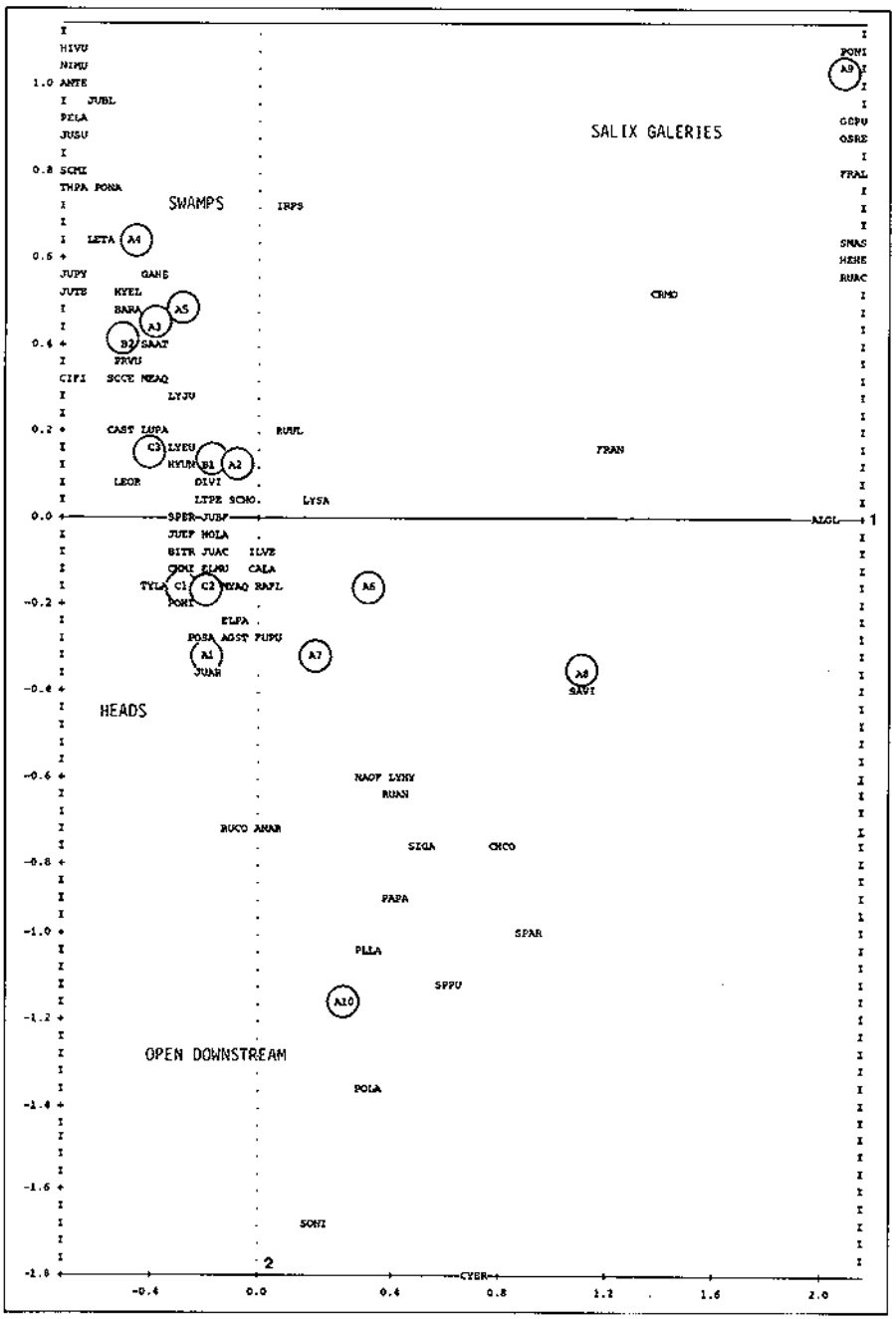

Figure 2. Factorial correspondance analysis applied to the whole of surveys. Only species found in more than 2/3 of the sites are represented.

lifeforms): i) obligate helophytes-*Myriophyllum aquaticum, Eleocharis palustris, Sparganium erectum, Typha latifolia;* ii) annuals - *Bidens tripartita, Chamaemelum mixtum, Illecebrum verticillatum, Juncus buffonius* and *Polygonum hydropiper;* iii) other herbs - *Agrostis stolonifera, Holcus lanatus, Hypericum undulatum, Juncus acutiflorus, J. effusus, Lotus uluginosus, Lycopus europaeus* and *Scirpus holoschoenus*; iv) shrubs - *Rubus ulmifolius* and *Dittrichia viscosa.*

DISCUSSION

Because of its small size, the Erra bassin is quite homogeneous from the geological and the climatological points of view, and in the heads the agricultural activities increase the general nutrient levels. As a result, a group of helophytes an annuals (e.g. B*idens tripartita* and *Polygonum hydropiper*) occur throughout the bassin. Interesting enough, there is a lower frequency of hydrophytes in the areas influenced by agriculture.

The occurence of non-eutrophic species like *Illecebrum verticillatum* might be connected with sandy litoral areas, rapidly leached.

Open downstream habitats tend to be colonized by ruderal species, and from driest places, thus being difficult to point out typical ones because of their occasional occurence. Susceptibility of each species for specific site characteristics.

Swamp formations are probably related to groundwater and rainfall. Typical species are mesotrophic (e.g. *Cicendia filiformis, Anagallis tenella and Juncus pygmaeus*) The community seems associated with time lenght since deforestation and agricultural abandonment. Consequently various stages of succession can be found. C3 swamp, with many annuals, has been abandoned recently and A7 probably a long time ago. B2 shows a evolution towards a peat-like formation(c.f. *Thelipteris palustris).*

In the heads, the agriculture land use gives rise to a vegetation that has similarities with the open downstream habitats'(*Anagallis arvensis, Rumex spp. Nasturtinum officinale, Paspalum paspalodes).* Furthermore, agriculture increase the nutrient status of the main stream, modifying the helophytic vegetation and

AGST - *Agrostis stolonifera*
ALGL - *Alnus glutinosa*
ANAR - *Anagallis arvensis*
ANTE - *Anagallis tenella*
BARA - *Baldellia ranunculoides*
BITR - *Bidens tripartitus cf.*
CALA - *Carex laevigata*
CAST - *Callitriche stagnalis*
CHCO - *Chrysanthemum coronarium*
CHMI - *Chamaemelum mixtum*
CIFI - *Cicendia filiformis*
CRMO - *Crataegus monogyna*
CYER - *Cyperus eragrostis*
DIVI - *Dittrichia viscosa*
ELMU - *Eleocharis multicaulis*
ELPA - *Eleocharis palustris*
FRAL - *Frangula alnus*
FRAN - *Fraxinus angustifolia*
FUPU - *Fuirena pubescens*
GAHE - *Galium helodes*
GEPU - *Geranium purpureum*
HEHE - *Hedera helix*
HIVU - *Hydrocotyle vulgaris*
HOLA - *Holcus lanatus*
HYEL - *Hypericum elodes*
HYUN - *Hypericum undulatum*
ILVE - *Illecebrum verticellatum*
IRPS - *Iris pseudacorus*
JUAC - *Juncus acutiflorus*
JUAR - *Juncus articulatus*
JUBF - *Juncus bufonius*
JUBL - *Juncus bulbosus*
JUEF - *Juncus effusus*
JUPY - *Juncus pygmaeus*
JUTE - *Juncus tenageia*
JUSU - *Juncus subnodulosus*
LEOR - *Leersia oryzoides*
LETA - *Leontodon taraxacoides*
LTPE - *Lotus pedunculatus*
LUPA - *Ludwigia palustris*
LYEU - *Lycopus europaeus*
LYHI - *Lythrum hissopifolium*
LYTJ - *Lytrum junceum*
LYSA - *Lytrum salicaria*
MEAQ - *Mentha aquatica*
MYAQ - *Myriophyllum aquaticum*
NAOF - *Nasturtium officinale*
NIMU - *Nitella mucronata*
OSRE - *Osmunda regelis*
PAPA - *Paspalum paspalodes*
PELA - *Peucedanum lancifolium*
PLLA - *Plantago lagopus*
POHI - *Polygonum hydropiper*
POLA - *Polygonum lapathifolium*
PONI - *Populus nigra*
PONA - *Potamogeton natans*
POSA - *Poligonum salicifolium*
PRVU - *Prunella vulgaris*
RAFL - *Ranunculus flammula*
RUAC - *Rusctes aculeatus*
RUAN - *Rumex angiocarpus*
RUCO - *Rumex conglomeratus*
RUUL - *Rubus ulmifolius*
SAAT - *Salix atrocinerea*
SAVI - *Salix alba-vitelina*
SCCE - *Scirpus cernuus*
SCHO - *Scirpus holoschoenus*
SCMI - *Scutellaria minor*
SIGA - *Sitlne gallica*
SMAS - *Smilax aspera*
SONI - *Solanum nigrum*
SPAR - *Sperguta arvensis*
SPER - *Sparganium erectum*
SPPU - *Spergularia purpurea*
THPA - *Thelipteris palustris*
TYLA - *Typha latifolia*

spreading some species throughout the whole course.. Nevertheless, the middlestream has a higher number of hydrophytes, like *Nitella mucronata, Potamogeton natans* and *Ludwigia palustris*.

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