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Influence of environmental factors on the chamaephytic vegetation of pebbly alluvium of southern Tuscan river beds (central Italy)

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SUMMARY

The results of an ecological and phytosociological study of the chamaephytic vegetation on the first two alluvial terraces of several river beds in southern Tuscany (central Italy) are reported. A strong correlation between the various plant communities and the degree of disturbance by flooding and with pedogenesis was observed. A new subassociation of *Santolino etruscae–Saturejetum montanae*, growing on terraces with incoherent substrate frequently disturbed by flooding, is described. Some fundamental factors, namely the ecological and structural features of the individual vegetation stands, clarify the autonomy and syntaxonomical collocation of the coenoses studied.

Key-words: Canonical Correspondence Analysis, central Italy, chamaephytic vegetation, flooding, syntaxonomy, water courses.

INTRODUCTION

The water courses of southern Tuscany (Provinces of Siena and Grosseto, central Italy) are characterized by an initial stretch with intense erosion, followed by a long gently sloping stretch with heavy sedimentation (AA.VV. 1971). These processes give the river beds the following characteristics: (i) a very wide sandy–pebbly bed, apparently disproportionate to the capacity of the water course, which is almost or completely dry in summer and subject to flooding around the autumn and spring; (ii) many braided channels; (iii) a series of relatively flat terraces having sharply eroded banks in the curves of the river.

The study area is situated in the heart of the distribution of the endemic suffrutex *Santolina etrusca* (Arrigoni 1979; Angiolini *et al.* 1996), in the hydrographic basin of the Orcia, Paglia, Fiora, Albegna and a small section of the Ombrone rivers (Fig. 1). Prevalently Mio-Pliocene clay–sand and conglomerate formations and Pliocene clay formations outcrop in this hilly landscape (Lazzarotto 1993). The vegetation includes: (i) a plain-to-hillside belt with mixed thermophilous oak woods having a prevalence of *Quercus cerris* (*Lonicero etruscae–Quercion pubescentis*) or mixed deciduous oak woods with a prevalence of *Q. cerris* and *Q. pubescens* (*Quercion pubescenti-petraeae*), depending on proximity to the coast or to the main reliefs (Mts Amiata, Cetona, Labro, etc.). An edaphoxerophilous variant consists of evergreen oak mixed with broadleafs (*Orno–*

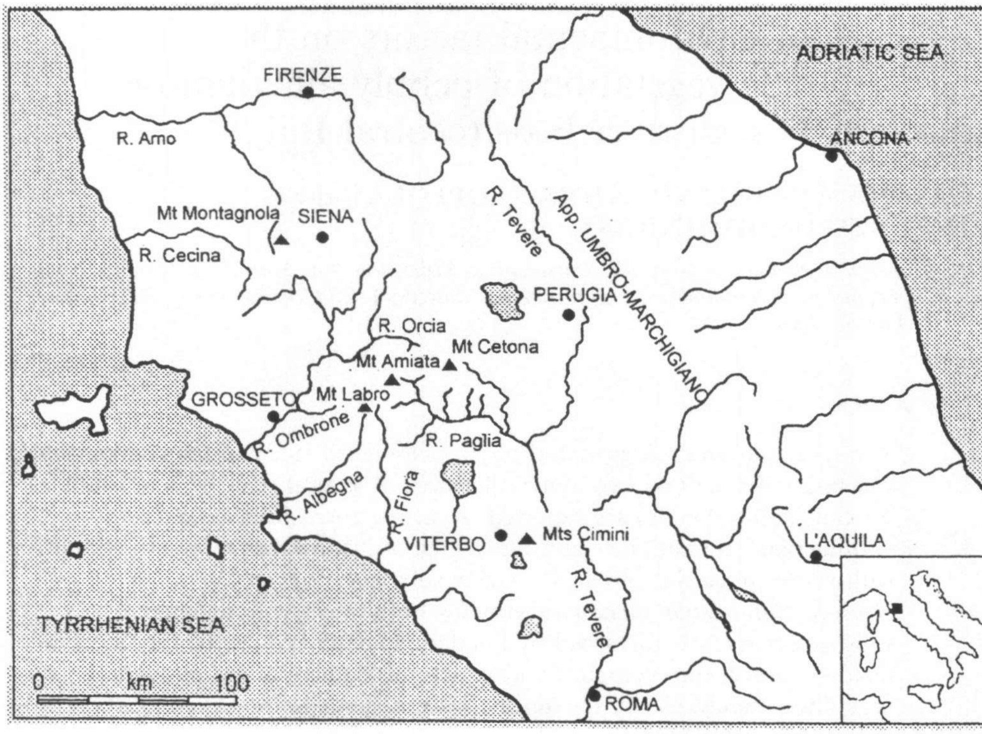

Fig. 1. Study area.

Quercetum ilicis) on stony, well drained soils and on slopes with southern and western exposures (De Dominicis 1993); (ii) a Mediterranean (temperate) belt with thermophilous evergreen oak woods (*Quercion ilicis*) (Pignatti 1979). For further details, see Arrigoni *et al.* (1990), Blasi (1994) and Angiolini & De Dominicis (1998).

In Italy, research on riparian vegetation has been concerned mainly with hygrophilous shrub, arboreal and herbaceous communities. Only recently has research been extended to chamaephytic vegetation of the sandy–pebbly alluvium of braided streams. These studies have been carried out principally in southern Italy and the islands, and have led to the description of various phytocoenoses (Ferro & Di Benedetto 1980; Brullo & Spampinato 1990; Biondi *et al.* 1994, 1996). Previous studies on the riparian vegetation in Tuscany and Latium are published in Scoppola & Angiolini (1997a, 1997b), Scoppola (1998) and Angiolini & De Dominicis (1998).

The aims of the present study were: (i) to compare the ecological and floristic features of chamaephytic phytocoenoses on the incoherent and compact alluvial substrates of the mid-to-lower stretches of several water courses in southern Tuscany; (ii) to determine any relationships between environmental factors and phytocoenoses in these environments; and (iii) to complete the synecological and syntaxonomical classification of the coenoses examined.

MATERIALS AND METHODS

In 1996, 27 relevés of pioneer subnitrophilous chamaephytic vegetation with *S. etrusca* were carried out on first river terraces (see Appendix I). Thirteen of these and 10

Table 1. Environmental parameters analysed in relation to vegetation gradient

Relevé no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Lichen and moss cover (%)	0	0	18	2	0	0	1	0	2	0	0	0	0	40	75	85	90	85	70	60	40	40	60
Distance to running water (m)	10	12	22	18	20	19	9	7	33	18	5·5	10	17	55	16	20	26	30	30	32	20	18	15
Terrace thickness (m)	1	0·9	2	1·2	1·4	1	1	0·5	2	0·3	0·35	1	0·8	1·6	1·7	2	2	2·2	2	2·1	2	2	2·1
Altitude (ma.s.l.)	220	220	280	340	340	280	340	338	35	78	35	36	38	335	350	280	280	340	105	100	40	35	32
Bank erosion	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0	1	1	1	1	1	0	1	1
Open valley	1	1	1	0	0	1	1	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0	0
Substrate stability	0	0	0	0	0	1	0	0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1
Skeleton (%)	88·6	77·71	27·98	72·49	38	30·93	80·36	85·7	69·53	88·67	81·74	78·86	55·44	94·42	78·39	81·67	67·81	16·08	85·42	60·77	79	76·37	70·27
Sand (%)	6·99	13·69	31·51	25·45	47·34	38·9	15·37	12·11	15·24	7·87	11·4	16·7	39·9	14·7	17	3·88	14·7	34·58	24·82	15·47	18·69	16·76	21·44
Mud (%)	4·36	8·60	40·51	2·07	14·65	30·17	4·27	2·19	15·24	3·46	6·85	4·43	4·7	3·66	4·58	1·7	3·66	49·34	7·36	8·16	20·54	4·25	8·28
pH	8·30	8·45	8·4	8·65	8·35	8·4	8·5	8·7	8·25	8·35	8·55	8·5	8·7	8·3	8·5	8·25	8·35	8·2	8·35	8·15	8·1	8·3	8·15
Organic C	0·45	0·45	0·6	1·03	0·9	0·62	0·31	0·62	0·49	0·25	0·45	0·39	0·31	0·73	0·93	0·59	0·59	0·89	0·53	0·65	0·39	0·39	0·62
Total N	0·05	0·05	0·01	0·01	0·02	0·04	0·04	0·05	0·13	0·04	0·08	0·07	0·04	0·05	0·06	0·06	0·06	0·06	0·06	0·04	0·07	0·07	0·08
C/N	9	9	55·1	74·16	45	15·5	7·75	12·4	3·77	6·25	5·63	5·57	7·75	14·6	18·6	9·83	9·83	14·8	8·83	16·3	5·57	5·57	7·75

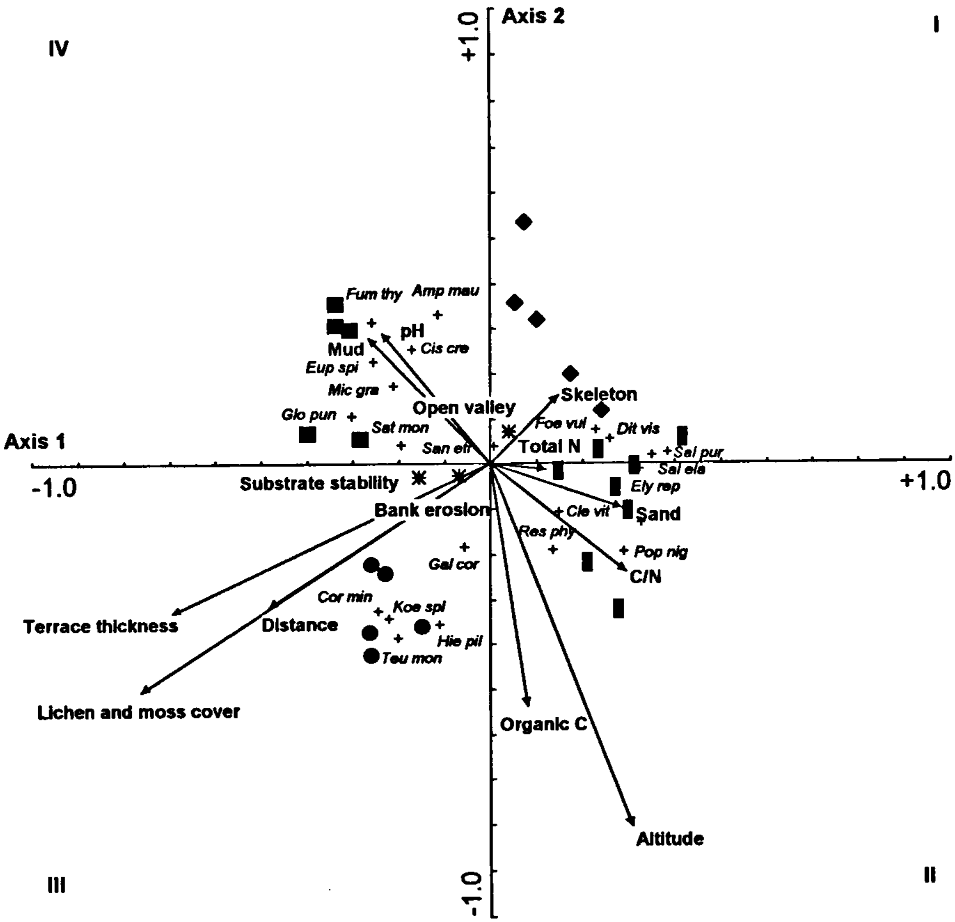

Fig. 2. CCA ordination diagram with relevés, species and environmental variables (arrows = quantitative variables, stars = nominal variables): ◆ first terrace coenoses (subcoastal variant); ▮ first terrace coenoses (inland variant); ■ *Santolino–Saturejetum montanae micromerietosum graecae*; ● *Santolino–Saturejetum montanae teucrietosum montani.*

bibliographic relevés by Scoppola & Angiolini (1997b), attributed partly to *Santolino–Saturejetum micromerietosum graecae* of subcoastal areas, and partly to *Santolino–Saturejetum teucrietosum montani* of the inland hill belt, were used to compare these phytocoenoses with those of stable terraces. Several environmental parameters were measured and three nominal variables recorded for 13 of the 27 relevés and for the 10 bibliographic relevés (Table 1). Soil samples were taken at depths between 0 and −10cm and the following parameters (Table 1) measured: particle size according to the scale of Wentworth (1922) and by the wet method according to ASTM D 2217 (1985); pH of the fraction having a particle size of <2mm, suspended 1:2·5 with distilled water (Società Italiana della Scienza del Suolo 1985); organic carbon by the modified method described in Gaudette *et al.* (1974) and total nitrogen by the method of Kjeldahl, deduced from Ministero delle Risorse Agricole, Alimentari e Forestali (1994), determined on the fraction having a particle size of <0·25mm.

Table 2. The intraset correlations of environmental variables with the first two axes of CCA. The values in bold are statistically significant

	Axis 1	Axis 2
Lichen and moss cover (%)	**−0·7579**	−0·4902
Distance to running water (m)	−0·4789	−0·3081
Terrace thickness (m)	**−0·6888**	−0·3210
Altitude (m a.s.l.)	0·3066	**−0·7829**
Bank erosion	−0·2740	−0·0944
Open valley	0·1400	0·2479
Substrate stability	**−0·6976**	−0·1248
Skeleton (%)	0·1431	0·1518
Sand (%)	−0·2649	0·2749
Mud (%)	0·2823	−0·0962
pH	−0·2338	0·2849
Organic C	0·0771	**−0·5225**
Total N	0·1187	−0·0115
C/N	0·2914	−0·2294

Canonical Correspondence Analysis (CCA) (Ter Braak 1987, 1991) was used to analyse the vegetation gradient. Ordination was performed with the program CANOCO 3.12 (Ter Braak 1991). Infrequent species were downweighted, otherwise standard options were used. The significance of the eigenvalues corresponding to the first axis and the environmental variables was tested by the Monte Carlo permutation test (Ter Braak 1991).

To characterize the vegetation, a matrix of 27 relevés × 63 species was constructed and processed by cluster analysis. The relevés were classified (Program NCLAS—package Syntax 5·0, Podani 1993) on the basis of cover data using the average linkage as clustering criterion and the percentage difference as dissimilarity index (Podani 1994). Species cover values in the matrices were transformed according to Van der Maarel (1979) and all quantitative 'skewed' variables that have a log-normal distribution were written as their base 10 logarithm to give them a normal distribution (Jongman *et al.* 1995).

RESULTS AND DISCUSSION

Synecology

The ordering of relevés and species in the CCA triplot diagram is shown in Fig. 2. The arrows indicate environmental gradients: their length and direction indicate correlations with the ordination axes and the variability pattern of the diagram. The nominal variables (stars) indicate the weighted centre (centroid) of the relevés characterized by that variable (Ter Braak 1986). The first two axes of the ordination explain 20·2% and 11·4%, respectively, of the variance of the species. The eigenvalue corresponding to the first canonical axis is highly significant ($P<0·01$), indicating significant differences in vegetation between samples. The first axis showed a statistically significant correlation with lichen and moss cover, terrace height and compact substrate (Table 2), separating the relevés of *Santolino–Saturejetum montanae* (compact alluvium, quadrants III and IV) from those in the incoherent alluvium (quadrants I and II).

Table 3. *Santolino–Saturejetum montanae* Scoppola & Angiolini 1997 *santolinetosum etruscae* subass. nova

Relevé group	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4
Relevé no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18*	19	20	21	22	23	24	25	26	27
Altitude (m a.s.l.)	280	280	270	220	220	350	350	340	220	280	340	340	340	338	338	105	105	36	36	38	75	75	35	35	78	35	78
Plot surface (sq. m)	25	25	30	25	25	25	25	30	20	25	25	20	25	25	30	25	20	30	30	25	20	25	25	25	30	25	20
Cover (%)	25	45	65	40	25	65	55	60	50	55	55	70	35	25	25	35	25	40	45	40	55	40	55	60	25	30	35
Water course	Or	Or	Elv	Fio	Fio	Fio	Fio	Fio	Pa	Or	For	For	Or	For	For	Or	Or	Omb	Omb	Omb	Tra	Tra	Alb	Alb	Tra	Mel	Tra
Number of species	16	23	24	25	28	20	20	24	28	18	31	19	24	27	31	23	21	24	21	22	21	21	20	21	26	22	19
Character and differential species of association																											
Santolina etrusca	2	2	4	3	2	3	3	3	3	3	3	2	1	1	1	2	1	2	2	2	2	2	2	2	1	2	1
Satureja montana	+	1	.	.	.	.	.	.	1	.	.	.	+	+	+	+	.	+	+	1	1	1	.	+	1	+	+
Melilotus neapolitana	+	+	.	.	.	+	+	+	.	+	.	+	.	.	.	+	+	+	.	+	+	.	+	+	.	+	.
Seseli tortuosum	.	+	+	.	.	.	.	.	.	1	1	.	+	.	.	1	.	+	.	.	.	.	.	.	+	+	.
Astragalus monspessulanus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Character and differential species of subassociation																											
Dittrichia viscosa	1	+	+	2	2	1	+	1	2	+	+	1	2	1	2	2	2	2	2	1	+	1	1	1	2	2	+
Clematis vitalba	+	.	.	1	+	2	2	1	1	.	.	2	+	.	1	.	.	.	.	.	1	1	1	1	+	+	.
Chondrilla juncea	.	.	.	+	.	.	.	+	.	.	1	.	.	.	.	.	.	+	+	+	r	.	+	.	+	.	.
Scrophularia canina	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Species of inland variant																											
Bromus erectus	+	+	1	+	+	+	+	1	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Phleum bertolonii	.	.	.	+	+	.	.	.	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Thymus longicaulis	.	+	+	+	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Koeleria splendens	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Galium corrudifolium	.	.	+	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Species of subcoastal variant																											
Ampelodesmos mauritanicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	1	1	1	1	1	+	1
Verbascum sinuatum	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	1	1	1	.	.	+	.	.	.	.
Character species of *Rosmarinetalia, Rosmarinetea officinalis*																											
Linum tenuifolium	1	+	+	.	+	+	+	+	+	+	+	.	+	+	.	+	+	.	.	.	+	+	+	+	+	+	.
Spartium junceum (seedlings)	.	.	+	+	+	.	.	+	1	1	+	1	.	+	.	1	.	+	.	+	.	r	.	.	+	+	+
Scabiosa atropurpurea	+	+	+	+	.	+	.	+	+	.	.	.	.	.	.	.	+	.	.	.	r	r	+	.	+	.	.
Thesium divaricatum	+	2	+	.	+	.	.	.	.	1	+	+	+	+	+	.	.	.	.	.	+	r	.	.	.	.	.
Dorycnium hirsutum	.	+	.	+	+	.	.	.	.	.	.	.	.	+	+	.	+	+	+	.	+	.	.	.	+	.	.
Cistus creticus ssp. *eriocephalus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	+	+	+
Convolvulus cantabrica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	1	+	.	.	+
Micromeria graeca	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	r	.	.	.	.	.
Teucrium montanum	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																											
Helichrysum italicum	1	1	1	1	1	2	1	2	+	+	2	1	2	1	+	1	1	2	2	3	3	2	3	3	2	1	3
Sanguisorba minor ssp. *muricata*	1	+	1	+	+	+	+	+	.	1	+	+	+	+	+	+	+	1	1	+	+	+	+	+	+	+	+
Hypericum perforatum	+	+	+	+	+	+	+	+	+	.	.	+	.	.	+	+	+	+	+	+	+	+	+	+	.	+	+
Foeniculum vulgare ssp. *piperitum*	.	+	.	+	+	+	+	+	1	+	+	.	+	+	.	+	+	+	.	.	+	+	+	+	+	+	+

Table 3. *continued*

Other species—*continued*																											
Anthemis tinctoria	.	1	+	+	1	1	1	+	+	1	1	1	+	+	+	2	1	1	1	1	.	.	.	.	.	.	.
Sonchus asper	+	.	+	+	+	.	+	.	.	.	.	.	+	+	.	+	+	.	+	+	+	.	+	+	+	+	+
Lolium multiflorum	.	.	.	+	+	.	.	.	+	.	+	.	.	.	.	+	+	.	+	+	+	+	+	+	+	+	+
Daucus carota	.	.	.	+	+	+	+	+	+	+	+	.	.	+	+	.	.	.	.	.	.	.	.	+	+	.	.
Galium album	.	.	.	.	+	+	+	+	+	+	+	+	.	.	+	+	.	.	.	.	.	+	.	.	+	.	.
Elymus repens	.	.	.	.	+	.	+	+	.	+	.	.	+	+	+	.	.	.	+	+	.	.	.	.	.	+	+
Brachypodium rupestre	.	.	.	+	+	+	.	+	+	+	.	.	+	+	.	.	.	.	.	.	.	+	.	.	+	.	.
Plantago lanceolata	.	.	.	+	.	.	.	.	.	.	+	.	.	+	+	.	+	.	.	+	+	.	.	.	+	+	+
Sedum sexangulare	+	+	+	.	+	.	+	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia cyparissias	.	.	.	+	+	.	+	.	+	.	+	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Xantium italicum	.	.	.	+	+	.	.	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	+	.	+
Hedysarum coronarium	+	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	+	.
Cichorium intybus	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.
Equisetum ramosissimum	.	.	+	.	.	.	.	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Sedum rupestre	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.
Reichardia picroides	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Urospermum dalechampii	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	+	.	.	+	.	.	.	.
Populus nigra (seedlings)	.	.	.	.	.	.	.	.	+	.	.	.	.	1	1	.	.	.	+	.	.	.	+	.	.	.	.
Calamintha nepeta	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.
Salix purpurea (seedlings)	.	.	.	.	+	.	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Galium aparine	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	.
Erysimum pseudorhaeticum	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.
Reseda phyteuma	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	+	.	.	.	.	.	.	.	.	.
Salix elaeagnos (seedlings)	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	1	.	.	.	.	.
Euphorbia terracina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1	.	.	.	.	1
Polygala flavescens	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juniperus communis (seedlings)	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Festuca arundinacea	.	.	.	.	.	.	.	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucanthemum pallens	.	.	.	.	.	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia vulgaris	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Plantago maritima	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agrostis stolonifera	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Rosa canina (seedlings)	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Tragopogon porrifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Sporadic species	0	3	2	1	2	2	0	0	4	0	4	0	2	3	3	1	2	2	2	2	1	0	0	3	3	3	2

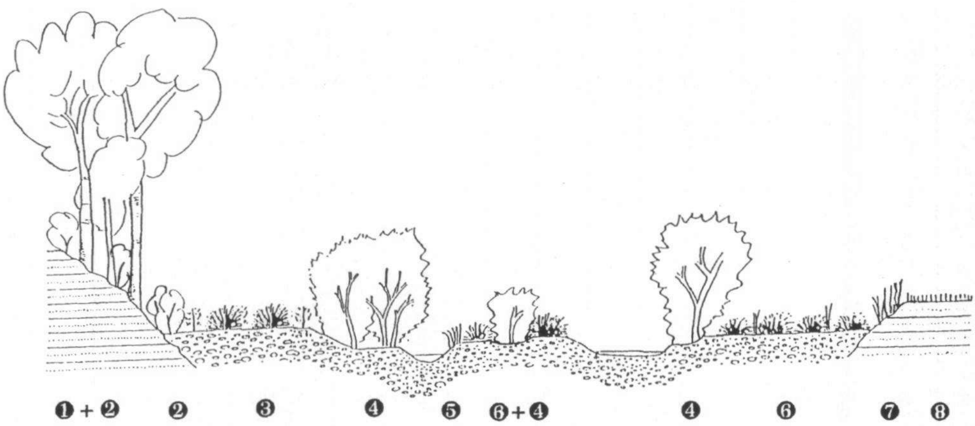

Fig. 3. Schematic cross-section through the vegetation of inland southern Tuscany stream beds: (1) Underwood of *Lonicero etruscae–Quercion pubescentis*. (2) *Cytision sessilifolii* fragm. (3) *Santolino–Saturejetum teucrietosum montani*. (4) *Saponario–Salicetum purpureae*. (5) *Bidentetalia tripartitae*. (6) *Santolino–Saturejetum montanae santolinetosum etruscae*. (7) *Inulo–Agropyrion*. (8) fields.

Hygrophilous and/or ruderal species such as *Salix purpurea*, *S. elaeagnos*, *Clematis vitalba*, *Populus nigra*, *Dittrichia viscosa* and *Elymus repens* appear in quadrants I and II of Fig. 2. Xerophilous garigue species including *Satureja montana*, *Euphorbia spinosa*, *Globularia punctata* and *Coronilla minima*, all excellent differential species of subassociations of *Santolino–Saturejetum montanae*, appear in quadrants III and IV.

The first axis of the CCA can therefore be interpreted as increasing disturbance due to flooding. In fact, one of the environmental factors regarded by many as significant for defining the species composition of riparian vegetation is the height of the terrace above the river (Brullo & Spampinato 1990; Malanson 1993; Scoppola & Angiolini 1997a). Lichen and moss cover and substrate stability/compactness are correlated with this factor. Hence our analysis shows clearly that the coenoses of the incoherent alluvium (quadrants I and II) are well differentiated in ecological and floristic terms from those of the consolidated alluvium, and can therefore not reasonably be classified as the *Santolino–Saturejetum micromerietosum* or *Santolino–Saturejetum teucrietosum*.

The second axis was significantly correlated with altitude (Table 2), in other words, the geographical site of the relevés, and hence with macroclimatic characteristics, from the inland hills (quadrants II and III) to the subcoastal belt (quadrants I and IV). This can also be seen in Fig. 2 where the distribution of species in quadrants III and IV confirms the autonomy of the two subassociations of *Santolino–Saturejetum montanae* described by Scoppola & Angiolini (1997b). The floristic differentiation of the more pioneer phytocoenoses in relation to edaphic and ephemeral factors is less evident along this altitude gradient.

The second axis was also correlated quite significantly with soil organic carbon content (Table 2), which increased from subcoastal to inland hill belt river beds. This could be related to climatic factors and the width of the river bed, as well as to the presence of arboreal vegetation on stable terraces of inland water courses.

The other soil variables (pH, total N, C/N, % skeleton, % of sand, % of mud) were not significantly correlated with the axes (Table 2). In fact, the soil characteristics were quite similar: all were alluvial soils in the very first stages of evolution, with physical modification more accentuated than chemical alteration, which was very weak; all were alkaline, porous, with texture that varied from place to place; soil skeleton was abundant and this, together with the prevalence of sand among fine material, explains the high permeability and low fertility.

Syntaxonomy

The dendrogram obtained from the classification of the 27 original relevés (not shown) shows good affinity between them; four groups, related to disturbance (first CCA axis) and geographical site (second CCA axis), emerge. The phytosociological table (Table 3) was therefore ordered according to the sequence obtained from the classification of the relevés. It describes the glareicolous phytocoenoses that colonize the recent sandy–pebbly alluvium which is periodically flooded but practically dry in summer. These communities are permanently pioneer in character because flooding and the continual deposition of new alluvium blocks the natural evolution of both the soil and the vegetation.

The clear ecological characterization and repetitiveness of the flora justify the description of a new subassociation of *Santolino–Saturejetum* (*Artemisio albae–Saturejïon montanae, Rosmarinetalia, Rosmarinetea officinalis*), which we call *santolinetosum etruscae* (type relevé no. 18, Table 3, *hoc loco*). This subassociation is linked prevalently to southern Tuscan water courses with wide beds. In northern Latium, where the stream beds are narrower and more natural, it has a more fragmented distribution (Scoppola 1998). It is a pioneer variant of *Santolino–Saturejetum* and it is poor in character species of the association and generally in the *Rosmarinetalia* component associated with stable alluvium. The instability of the habitat favours the frequency of *Dittrichia viscosa, Clematis vitalba, Chondrilla juncea* and *Scrophularia canina*, which are thus differential species of the new subassociation. We have observed previously that *D. viscosa* and *C. vitalba* may also be found in more mature forms of vegetation as a result of habitat disturbance (Scoppola & Angiolini, 1997b). *C. vitalba*, with its typical prostrate habitus, is further evidence of the degree of alteration of the substrate and of frequent disturbance. Species such as *Foeniculum vulgare, Lolium multiflorum, Daucus carota, Plantago lanceolata* and *Elymus repens*, from neighbouring uncultivated areas, are also present. The great instability of these habitats is shown by the floristic heterogeneity of the coenoses. Remodelling by floodwaters is also associated with the periodic appearance of hygrophilous species.

The subassociation *santolinetosum etruscae* has at least two variants typical of, respectively, inland hillsides and subcoastal belts. The first includes groups 1–3 of the classification (relevés 1–15), including coenoses of inland stream beds between altitudes of 220 and 350m. *Phleum bertolonii, Thymus longicaulis, Bromus erectus*, etc. are concentrated in these relevés. Group 1 is the closest to the subassociation *teucrietosum montani*. Group 3 (relevés 13–15) exemplifies areas of contact with hygrophilous and pioneer coenoses of recent alluvium (*Bidentetalia tripartitae, Salicetalia purpureae*, Fig. 3) in environments in which the terrace is not very thick.

Relevés 16–27 exemplify the subcoastal variant by virtue of the addition of more Mediterranean species such as *Ampelodesmos mauritanicus* and *Verbascum sinuatum*. On land subject to human disturbance, this variant sometimes comes into contact with the subassociation *micromerietosum* (e.g. along the rivers Melacce and Orcia).

Since these garigues do not have floristic originality in comparison with more mature garigues on compact alluvium and belong in a Mediterranean hill-belt bioclimatic context, we do not consider it appropriate to shift them from *Rosmarinetalia* to *Helichryso–Santolinetalia* (*Pegano–Salsoletea*). Inside this syntaxon, in the thermo-Mediterranean context of the subcoastal belt of Sicily, Calabria and Lucania, Biondi *et al.* (1994) have described the alliance *Artemision variabilis* from southern Italy for chamaephytic vegetation of sandy–pebbly, periodically flooded stream beds as a vicariant of *Artemisio–Santolinion rosmarinifoliae* of the Iberian peninsula. *Artemision variabilis* is characterized by *Artemisia variabilis, Helichrysum italicum, Dittrichia viscosa* and *Chondrilla juncea.*

CONCLUDING REMARKS

The description of a new subassociation of *Santolino–Saturejetum montanae* emerges from the study of the vegetation of pebbly–sandy alluvium of southern Tuscan river beds, especially that of less stable substrates. The presence of either subassociation is therefore mainly related to terrace thickness and degree of disturbance by flooding, being practically unaffected by soil variables other than organic carbon.

These results also confirm the observations of Angiolini & De Dominicis (1998) on the cover and density of *S. etrusca* in river beds; this species achieves its optimum in the new subassociation.

The present study also shows that, in the phytosociological characterization of communities, greater weight will have to be given to their ecological and structural features, as pointed out by various authors (Tüxen 1970; Pignatti *et al.* 1995; Schaminée & Stortelder 1996).

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APPENDIX I

List, site, date and sporadic species in relevés of Table 3

Rel. 1. F. Orcia 25-06-1996; Rel. 2. F. Orcia 25-06-1996. *Hieracium pilosella* (+), *Aster linosyris* (+), *Elymus pungens* (+); Rel. 3. T. Elvella 15-07-1996. *Hippocrepis comosa* (+), *Petroragia saxifraga* (+). Rel. 4. F. Fiora 06-06-1996. *Melilotus alba* (+); Rel. 5. F. Fiora 06-06-1996. *Knautia purpurea* (+), *Dorycnium penthaphyllum* (+); Rel. 6. F. Fiora 07-06-1996. *Jasione montana* (+), *Silene latifolia* ssp. *alba* (+); Rel. 7. F. Fiora 07-06-1996; Rel. 8. F. Fiora 07-06-1996; Rel. 9. F. Paglia 08-07-1996. *Silene vulgaris* (+), *Hieracium pilosella* (+), *Centaurea* gr. *jacea* (+), *Scabiosa triandra* (+); Rel. 10. F. Orcia 25-06-1996; Rel. 11. T. Formone 03-07-1996. *Scirpus holoschoenus* (1), *Artemisia cretacea* (+), *Senecio erucifolius* (+), *Lotus corniculatus* (+), *Scabiosa triandra* (+); Rel. 12.T. Formone 03-07-1996; Rel. 13. F. Orcia 27-06-1996. *Dorycnium penthaphyllum* ssp. *herbaceum* (+), *Poa compressa* (+). Rel. 14. T. Formone 02-07-1996. *Clinopodium vulgare* (+), *Eupatorium cannabinum* (+), *Centaurea* gr. *jacea* (+). Rel. 15. T. Formone 02-07-1996. *Clinopodium vulgare* (+), *Eupatorium cannabinum* (+), *Quercus pubescens* (seedling) (+). Rel 16. F. Orcia 18-06-1996. *Eryngium campestre* (+). Rel 17. F. Orcia 18-06-1996. *Phalaris aquatica* (+), *Andryala integrifolia* (+). Rel 18. F. Ombrone 31-05-1996. *Dianthus sylvestris* (+), *Silene dioica* (+). Rel. 19. F. Ombrone 31-05-1996. *Poa trivialis* ssp. *sylvicola* (+), *Alopecurus pratensis* (+). Rel. 20. F. Ombrone 31-05-1996. *Dianthus sylvestris* (+), *Vicia cracca* (+). Rel. 21. T. Trasubbie 24-05-96. *Eryngium campestre* (+). Rel. 22. T. Trasubbie 24-05-96. Rel. 23. F. Albegna 21-05-1996. Rel. 24. F. Albegna 21-05-1996. *Rosa sempervirens* (1); *Corynephorus divaricatus* (+), *Stachys ocymastrum* (+). Rel. 25. T. Trasubbie 27-05-1996. *Carex flacca* (+); *Asperula cynanchica* (+); *Crupina vulgaris* (+). Rel. 26. T. Melacce 30-05-1996. *Centaurea alba ssp. deusta* (+), *Fumana thymifolia* (+), *Teucrium chamaedrys* (+). Rel. 27. T. Trasubbie 27-05-1996. *Silene italica* (+), *Phleum arenarium* (+).

Syntaxa cited in text

Artemisio–Santolinion rosmarinifoliae Costa 1975; *Artemisio albae–Saturejion montanae* Allegrezza *et al.*, 1997; *Artemision variabilis* Biondi *et al.*, 1994; *Helichryso–Santolinetalia* Peinado & Martinez-Parras 1984; *Inulo viscosae-Agropyrion repentis* Biondi & Allegrezza, 1996; *Lonicero etruscae–Quercion pubescentis* Arrigoni & Foggi, 1988; *Orno–Quercetum ilicis* Horvatìc (1956), 1958; *Pegano-Salsoletea* Br.-Bl. & Bolòs, 1958; *Quercion ilicis* Br.-Bl. (1931), 1936; *Quercion pubescenti-petraeae* Br.-Bl. 1931; *Rosmarinetalia officinalis* Br.-Bl. 1931 em. 1952; *Rosmarinetea officinalis* Br.-Bl. 1947 em. Riv.-Mart., Diaz, Prieto, Loidi & Penas 1991; *Santolino etruscae–Saturejetum montanae* Scoppola & Angiolini, 1997; *Santolino etruscae–Saturejetum montanae micromerietosum graecae* Scoppola & Angiolini, 1997; *Santolino etruscae–Saturejetum montanae teucrietosum montani* Scoppola & Angiolini, 1997.