THE SYNTAXONOMIC POSITION OF *SANTOLINA ETRUSCA* – MULTIVARIATE ANALYSIS

CLAUDIA ANGIOLINI, VINCENZO DE DOMINICIS

Dipartimento di Biologia Ambientale, Università degli Studi di Siena
Via P.A. Mattioli 4, I – 53100 Siena, Italy

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ABSTRACT

The results of multivariate analysis of the syntaxonomic role of *Santolina etrusca* (Lacaita) Marchi et D'Amato, a species endemic to Tyrrhenian central Italy, are reported. Classification was performed by polythetic divisive analysis using two-way indicator species (TWINSPAN). Ordination analysis was performed by correspondence analysis (CA). Classification and ordination showed that although *Santolina etrusca* grows prevalently in communities of *Rosmarinetalia* Br.-Bl. ex Molinier 1934, it is ecologically correlated and associated with entities of unstable nitrophilous communities subject to frequent disturbance belonging to an order, *Helichryso-Santolinetalia* Peinado and Martinez-Parras 1984, with western eumediterranean distribution. However it does not have a well defined sociological role, as it is constant in all community groups.

KEY WORDS: *Santolina etrusca*, syntaxonomy, central Italy, TWINSPAN, CA.

INTRODUCTION

Santolina etrusca (Lacaita) Marchi et D'Amato is endemic to Tyrrhenian central Italy, and has a distribution that includes Tuscany, Umbria and Latium (Arrigoni 1979; Angiolini et al. 1996). In Latium it is reported to be threatened (Conti et al. 1997). This xerophilous species grows prevalently in garigues and chamaephytic grasslands of braided water courses and carbonate substrates. From the phytosociological point of view, a) it is a characteristic species of *Santolino etruscae-Saturejetum montanae* Scoppola and Angiolini 1997, an association that includes chamaephytic communities of stable river terraces; this syntaxon was first placed in *Xerobromion* (Br.-Bl. and Moor 1938) Moravec et al. 1967 (Scoppola and Angiolini 1997a) and later in *Rosmarinetalia* Br.-Bl. ex Molinier 1934, due to its geographic collocation and the presence of species such as *Ononis pusilla*, *Staehelina dubia*, *Fumana thymifolia* and *Teucrium capitatum* (Scoppola and Angiolini 1997b); b) it is differential of a clastic soil variant of Tuscan-Latium communities belonging to *Cephalario-Saturejetum* Allegrezza et al. 1997 (*Rosmarinetalia*) (Scoppola and Angiolini 1997b), an association described for dense, low, well structured garigue of carbonate lithosols of the Umbria-Marches Apennine (Allegrezza et al. 1997); c) it is a geographic differential of communities belonging to *Phleo-Bromion* Biondi and Blasi ex Biondi et al. 1995 (*Brometalia* Br.-Bl. 1936), of the hill and montane belt of carbonate outcrops of southern Tuscany (Angiolini and De Dominicis in press).

However Angiolini et al. (1998) report that *S. etrusca* seems to find its ecological optimum in glareicolous, subnitrophilous communities of *Santolino-Saturejetum santolinetosum* Angiolini et al. 1998, that colonize large areas of sandy-pebbly river terraces with incoherent substrate. This subassociation is ecologically and floristically related to *Helichryso-Santolinetalia* Peinado and Martinez-Parras 1984, of the Iberian peninsula that includes chamaephytic, subnitrophilous communities of the meso and supramediterranean belts dominated by composites of the genera *Helichrysum*, *Santolina* and *Artemisia* (Peinado and Martinez-Parras 1984; Peinado et al. 1988). This order has a eumediterranean and western distribution and in Italy it is only found in some southern regions with an endemic alliance, *Artemision variabilis* Biondi et al. 1994, that includes communities of river beds with medium-coarse pebbly substrate (Biondi et al. 1994). In Tuscany it fails to express, except as single elements.

The syntaxonomic position of *S. etrusca* is therefore difficult to define, because its phytosociological pattern is similar to that of other Spanish species of the genus *Santolina*, which penetrate the more stable basophilous communities of *Rosmarinetalia* or *Brometalia* and subnitrophilous communities subject to disturbance (*Helichryso-Santolinetalia*) (Font Castell 1993; López Udias et al. 1997; Mucina 1997; Peinado et al. 1988).

In view of the importance of detailed studies on plant endemisms (Major 1988), the aim of the present study is to clarify the phytosociological position of *S. etrusca* by multivariate analysis.

METHODS

Phytosociological relevés from the study of communities with *S. etrusca* (Scoppola and Angiolini 1997b; Angiolini et al. 1998; Angiolini and De Dominicis, in press) and 42 original relevés were used. The observations of Delpech (1983) and Ghirelli et al. (1995) were taken into account. A matrix

of 108 relevés by 45 species was constructed for the analysis, using only characteristic and differential species of the orders *Rosmarinetalia*, *Brometalia* and *Helichryso-Santolinetalia*, including their subordinate ranks; species belonging to the first frequency class were not used. The first two of these syntaxa include communities with *S. etrusca*; the third was used because many species of the genus *Santolina* from Spain are among its characteristic species and it is floristically and ecologically similar to the subassociation *santolinetosum* of *Santolino-Saturejetum*. Since sociological affinities of a taxon for syntaxonomic units are often of regional value, syntaxonomic references of taxa from Italian authors (Biondi et al. 1994, 1995; Allegrezza et al. 1997; Angiolini et al. 1998) were used.

The matrix was processed by multivariate analysis. The cover/abundance values obtained using the Braun-Blanquet scale were transformed into ordinal scale values (van der Maarel 1979; Noest et al. 1989) in the following way: +– 2, 1-3, 2-5, 3-7, 4-8, 5-9. The vegetation and species were classified using a polythetic divisive method, TWINSPAN (two-way indicator species analysis, Hill 1979), to obtain the dendrogram of Fig. 1. The default values of the program were used, except that the cut levels for the pseudospecies were set at 0, 2, 3, 5, 7.

The data was then ordered. Since it was collected along an environmental gradient, in the likelihood of a major coenocline, a unimodal model was considered to be appropriate (ter Braak 1987, Jongman et al. 1995). Correspondence Analysis (CA) was used for indirect analysis of gradient by means of the CANOCO version 3.12 software package (ter Braak 1991).

The taxonomic nomenclature is that of Tutin et al. (1964-1980, 1993) except for *S. etrusca*, for which we used the nomenclature of Pignatti (1982), because Tutin et al. (1976) do not consider new species of the genus *Santolina* identified in Italy by Marchi et D'Amato (1973) and Arrigoni (1979), but list only *S. chamaecyparissus* sp. pl. for the Italian peninsula.

RESULTS AND DISCUSSION

The first three levels of the TWINSPAN-classification are shown in the dendrogram of Fig. 1. The indicator species for each division are shown in decreasing order of significance. In the first cluster TWINSPAN divided the relevés into two clearly divergent main groups (Fig. 1: groups 1-4 and 5-8). The relevés of groups 1-4 are garigues and grasslands of stable environments, whereas those of groups 5-8 are chamaephytic communities of river terraces, frequently remodelled by flooding or human interference.

The groups emerging from the classification of the relevés and species are shown in Table 1. Corresponding syntaxa frequency and cover are shown in Table 2. Each group of relevés in Table 1 is characterized by a group of differential species; the species of *Rosmarinetalia*, *Brometalia* and *Helichryso-Santolinetalia* are indicated by R, B and HS respectively.

The group of species to which *S. etrusca* belongs includes exclusively species of *Helichryso-Santolinetalia* (*Helichrysum italicum, Chondrilla juncea, Dittrichia viscosa, Clematis vitalba*); as shown in Table 2, these species and *S. etrusca* have maximum frequency and cover in groups 6-7 of the classification. Of these, group 6 is the inland variant of the subassociation *santolinetosum* of *Santolino-Saturejetum* and group 7 is the subcoastal variant with high constancy of *A. mauritanicus*. Groups 5 and 8 each consist of a single relevé, are a variant with *Dittrichia viscosa* of *Santolino-Saturejetum* typical of situations in which evolved vegetation of the outer river terraces (major cover of garigue and grassland entities)

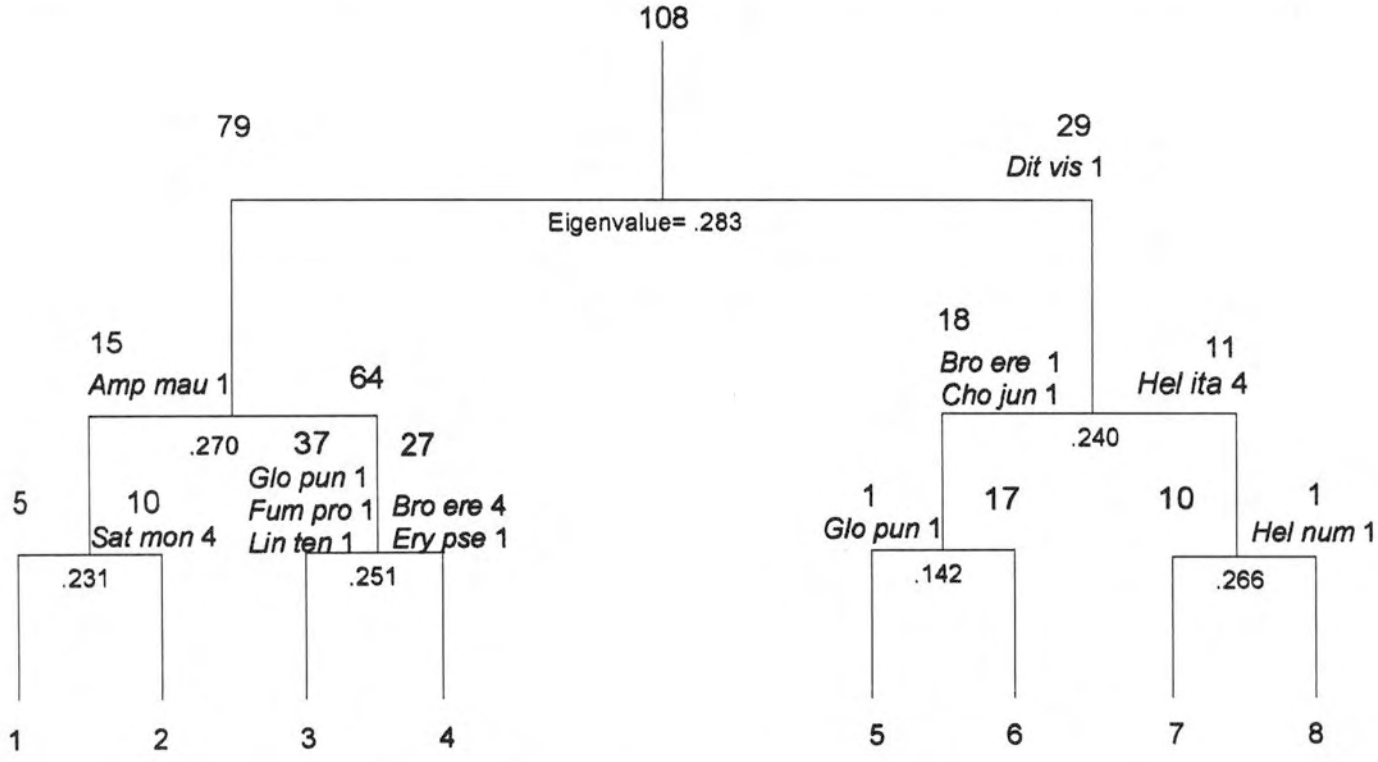

Fig. 1. TWINSPAN classification of the data set. The numbers above the abbreviations of the species refer to the number of samples in each cluster. Numbers after three-letter abbreviations give coverage cut levels for indicator species/pseudospecies.

TABLE 1. Summary of species composition of the eight groups obtained by clustering analysis. Roman numerals indicate percentage frequency (F) of species (V = ≥ 81%; IV = 61-80%; III = 41-60%; II = 21-40%; I ≤ 20%); arabic numbers indicate mean percentage cover (C) (the symbol "+" indicates mean cover ≤ 0.01%) in cluster groups.

		Classification group	1	1	2	2	3	3	4	4	5	6	6	7	7	8
		No. of relevés	5	5	10	10	37	37	27	27	1	17	17	10	10	1
			F	C	F	C	F	C	F	C	C	F	C	F	C	C
000	B	*Petrorhagia saxifraga*	II	0.04	III	0.05	II	0.36	–	–	–	–	–	–	–	–
000	B	*Dichantium ischaemon*	II	0.04	II	0.27	II	0.09	–	–	–	–	–	–	–	–
000	R	*Teucrium capitatum*	II	1.52	V	3.52	III	1.83	III	0.86	–	–	–	–	–	–
000	R	*Asperula cynanchica*	–	–	III	0.05	I	0.08	I	+	–	–	–	–	–	–
000	R	*Fumana thymifolia*	I	0.22	III	1.26	–	–	–	–	–	–	–	–	–	–
000	R	*Euphorbia spinosa ssp. spinosa*	–	–	I	0.27	–	–	–	–	–	–	–	–	–	–
000	R	*Globularia punctata*	–	–	IV	2.31	IV	3.12	–	–	+	–	–	–	–	–
000	R	*Fumana procumbens*	–	–	III	2.53	V	5.41	I	0.19	+	–	–	–	–	–
000	R	*Staehelina dubia*	–	–	–	–	II	0.35	–	–	–	–	–	–	–	–
000	B	*Carex cariophyllea*	–	–	–	–	II	0.28	–	–	–	–	–	–	–	–
000	B	*Arabis sagittata*	–	–	–	–	I	0.02	–	–	–	–	–	–	–	–
000	B	*Coronilla minima*	–	–	I	0.25	III	0.76	–	–	–	–	–	–	–	–
000	B	*Hieracium pilosella*	–	–	–	–	III	0.44	I	+	+	–	–	–	–	+
000	B	*Carex flacca*	II	0.04	–	–	II	0.09	I	0.11	–	–	–	–	–	–
000	R	*Osyris alba*	–	–	–	–	I	+	I	0.29	–	–	–	–	–	–
000	B	*Eryngium campestre*	II	0.04	–	–	II	0.09	IV	3.06	–	–	–	–	–	–
000	B	*Anacamptis pyramidalis*	–	–	–	–	I	+	II	0.02	–	–	–	–	–	–
000	B	*Dianthus carthusianorum*	–	–	–	–	I	+	I	0.19	–	–	–	–	–	–
000	B	*Aster linosyris*	–	–	–	–	I	+	II	0.02	–	–	–	–	–	–
001	B	*Galium corrudifolium*	–	–	II	0.02	IV	0.59	IV	1.69	+	I	0.02	–	–	–
001	B	*Thymus longicaulis*	I	0.02	IV	0.06	IV	0.79	IV	3.06	–	II	0.04	I	0.01	–
001	B	*Teucrium chamaedrys*	I	0.02	II	0.51	III	0.44	IV	5.61	–	–	–	–	–	–
001	B	*Koeleria splendens*	–	–	–	–	III	0.57	III	1.14	+	I	0.02	–	–	–
001	R	*Convolvulus cantabrica*	I	0.5	IV	1.25	III	0.31	II	0.58	–	–	–	III	0.29	–
001	B	*Bromus erectus*	III	0.06	V	0.58	IV	2.39	V	24.1	1	IV	0.35	–	–	–
001	B	*Helianthemum nummularium*	–	–	–	–	II	0.16	I	0.02	–	–	–	–	–	+
001	B	*Leontodon hirtus*	–	–	–	–	I	0.15	I	+	–	–	–	–	–	+
001	B	*Teucrium montanum*	–	–	–	–	III	0.69	–	–	1	I	0.15	–	–	+
010	R	*Thesium divaricatum*	–	–	–	–	IV	1.92	III	0.59	–	III	0.34	I	+	–
010	R	*Scabiosa atropurpurea ssp. maritima*	III	1.02	II	0.03	II	0.17	III	0.49	–	III	0.05	II	0.02	–
010	B	*Astragalus monspessulanus*	–	–	I	0.02	II	0.15	I	+	–	I	+	–	–	+
011	R	*Satureja montana*	III	3.5	V	20	IV	18.1	II	2.29	+	III	0.32	V	1.05	3
011	R	*Micromeria graeca*	III	0.54	V	0.82	I	+	–	–	–	I	+	I	+	–
011	R	*Cistus creticus ssp.eriocephalus*	V	7.54	V	1.96	II	2.3	I	0.1	–	–	–	III	0.05	+
100	R	*Linum tenuifolium*	–	–	I	0.02	V	0.8	I	+	–	V	0.22	III	0.06	1
100	R	*Dorycnium hirsutum*	–	–	I	0.02	III	0.11	I	+	1	II	0.04	II	0.04	+
100	B	*Sanguisorba minor ssp. muricata*	II	0.04	III	0.05	V	0.48	IV	1.16	+	IV	0.52	IV	0.58	+
101		*Santolina etrusca*	V	2.02	V	6.03	V	6.53	V	3.74	2	V	16.8	V	6.54	1
101	HS	*Helichrysum italicum*	IV	0.56	V	4.4	V	4.06	V	5.59	1	V	13.1	V	30	2
101	HS	*Chondrilla juncea*	–	–	–	–	I	+	I	+	+	V	0.25	III	0.1	–
101	HS	*Dittrichia viscosa*	–	–	–	–	–	–	–	–	1	V	1.9	V	2.16	+
101	HS	*Clematis vitalba*	–	–	–	–	I	+	–	–	+	III	1.28	III	1.74	–
110	R	*Ampelodesmos mauritanicus*	V	26.1	V	4.89	–	–	–	–	–	I	+	IV	1.2	–
111	B	*Brachypodium rupestre*	–	–	–	–	I	+	III	2.67	+	III	0.05	II	0.02	–
111	B	*Euphorbia cyparissias*	–	–	–	–	I	+	–	–	+	II	0.05	–	–	–

is penetrated by pioneer species as a result of disturbance (Scoppola and Angiolini 1997b). Groups 1-4 include: communities dominated by *A. mauritanicus* belonging to *Rosmarinetalia* (group 1), garigues of stable river terraces of the subcoastal belt (*Santolino-Saturejetum micromerietosum*), of the inland hill belt (*Santolino-Saturejetum teucrietosum*) and of carbonate substrates (*Cephalario-Saturejetum*) belonging to *Rosmarinetalia* (groups 2 and 3), and grasslands of the higher outer river terraces and the hill and montane belts of calcareous reliefs of southern Tuscany, belonging to *Brometalia* (group 4). Here the species of *Rosmarinetalia* and *Brometalia* prevail in terms of frequency and cover over species of disturbed environments (Table 2).

In the CA ordering (Fig. 2) the first two axes explain 12.9 and 11.9% of the variance of the species. The first axis represents a gradient of increasing disturbance because it separates relevés of stable environments from those of disturbed ones. The weighted average of the species in their relevés fall in the negative quadrants for the indicator species of groups 1-4 and in the positive quadrants for the indicator species of

TABLE 2. Summary of the relevés divided into TWINSPAN groups; groups 5 and 8 are excluded because they contained only one relevé each.

Classification group No of. relevés	1 5	2 10	3 37	4 27	6 17	7 10
Mean frequency of						
Brometalia	5	4.2	7.9	6.6	3.5	1.3
Rosmarinetalia	4.6	8.8	6.8	3	3	4
Helichryso-Santolinetalia	0.8	1	1.24	1.15	3.5	2.9
Mean cover of						
Brometalia	0.3	1.9	14	46	1.2	0.6
Rosmarinetalia	41	38	35	5	2	3
Helichryso-Santolinetalia	0.6	4.5	4.4	6	17	34

groups 7 and 8, typical of *Helichryso-Santolinetalia*, including *S. etrusca*. The second axis can be interpreted as a gradient of altitude, along which the communities of *Brometalia* and *Rosmarinetalia* are distributed. At the negative end, we have meso-xerophilous grasslands of the hill and montane belts and grassland species; at the positive end we have groups with clear Mediterranean character dominated by *A. mauritanicus*, and entities of thermophilous garigues. The communities of *Santolino-Saturejetum santolinetosum* and *S. etrusca* are only marginally affected by this gradient.

In conclusion, the present results show a clear correlation in terms of ecology and association, between *S. etrusca* and species characteristic of *Helichryso-Santolinetalia*. This is in line with the opinions of Angiolini et al. (1998) who sustain that this species belongs to frequently disturbed pioneer communities, poor in species of *Rosmarinetalia* associated with compact alluvium. The instability of the habitat favours species typical of *Artemision variabilis* and *Helichryso-Santolinetalia*, such as *Helichrysum italicum, Dittrichia viscosa, Clematis vitalba* and *Chondrilla juncea*. As observed in Sardinia in communities with *Santolina insularis* (Biondi et al. 1996), these entities give the communities of *Rosmarinetalia* a transition character towards *Helichryso-Santolinetalia*, which only expresses in a marginal way in Tuscany.

On the other hand, *S. etrusca* does not show a close correlation with the species of stable garigues on relatively impermeable carbonate substrates, belonging to *Rosmarinetalia*, and can therefore not be regarded as characteristic of this syntaxon. The fact that *S. etrusca* is found with rather low cover in the garigues and chamaephytic grasslands most typical of *Rosmarinetalia*, and marginally of *Brometalia*, is presumably linked to the frequent spatial and dynamic relations between

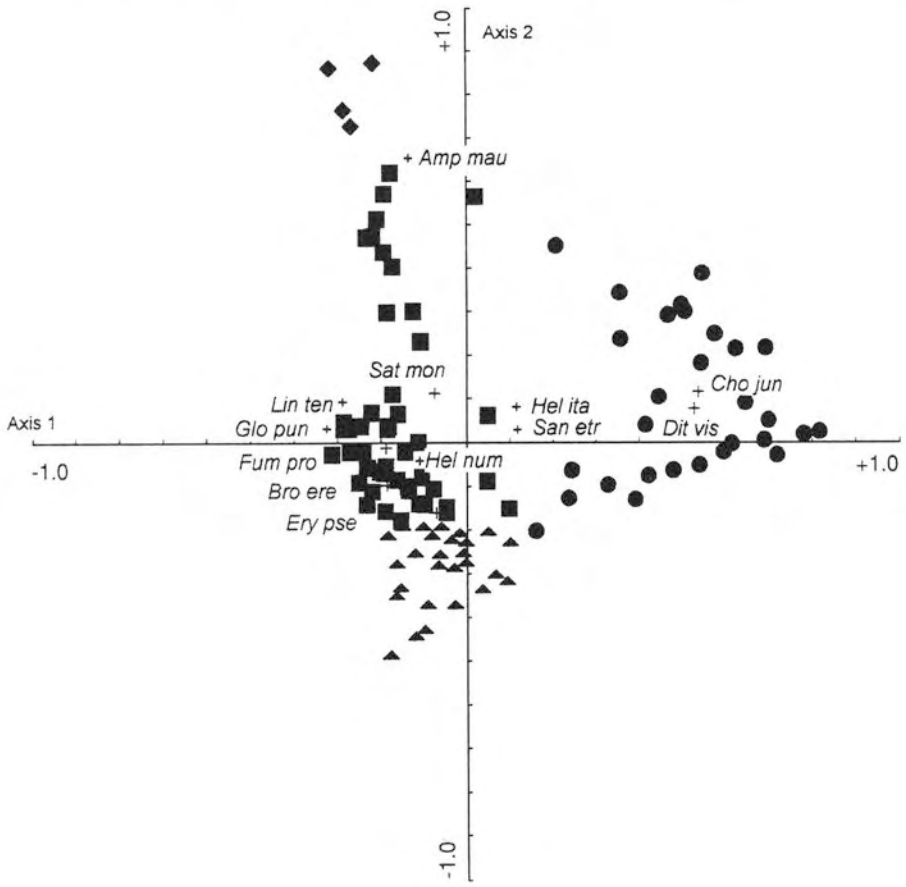

Fig. 2. Ordination diagram with axes 1 and 2 from Correspondence Analysis (CA) of 108 relevés and species. Only species found to be indicators in the TWINSPAN classification and *S. etrusca* are indicated. Species names are given as first-three-letter abbreviations. In the diagram ● = *Santolino-Saturejetum santolinetosum*; ■ = *Santolino-Saturejetum* and *Cephalario-Saturejetum*; ▲ = communities of *Brometalia*; ◆ = communities with *A. mauritanicus* (*Rosmarinetalia*).

these communities and less stable ones in the study area, and to the presence of clastic or coarse soil, as suggested by Scoppola and Angiolini (1997b).

However, *S. etrusca* does not have a well defined syntaxonomic role, showing wide ecological versatility in its area of distribution and growing in a variety of environmental and sociological conditions. It is constant in many community groups differentiated from a floristic, ecologic and dynamic point of view.

APPENDIX

Relevé source:

Gr. 1-5 unpublished relevés; Gr. 2-4 unpublished relevés, 6 relevés from Scoppola and Angiolini (1997 b) (*Santolino-Saturejetum micromerietosum*); Gr. 3-12 unpublished relevés, 25 relevés from Scoppola and Angiolini (1997 b) (*Santolino-Saturejetum teucrietosum* and *Cephalario-Saturejetum*); Gr. 4-21 unpublished relevés, 1 relevé from Scoppola and Angiolini (1997 b) (*Santolino-Saturejetum teucrietosum*) and 5 relevés from Angiolini and De Dominicis (submitted) (*Phleo-Bromion*); Gr. 5-1 relevé from Scoppola and Angiolini (1997 b) (*Dittrichia viscosa* variant of *Santolino-Saturejetum*); Gr. 6-17 relevés from Angiolini et al. 1998 (*Santolino-Saturejetum santolinetosum*); Gr. 7-10 relevés from Angiolini et al. 1998 (*Santolino-Saturejetum santolinetosum*); Gr. 8-1 relevé from Scoppola and Angiolini (1997 b) (*Dittrichia viscosa* variant of *Santolino-Saturejetum*).

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SYNTAKSONOMICZNA POZYCJA *SANTOLINA ETRUSCA*: ANALIZA WIELOWYMIAROWA

STRESZCZENIE

Praca przedstawia wyniki wielowymiarowej analizy dotyczącej syntaksonomicznej pozycji *Santolina etrusca* (Lacaita) Marchi et D'Amato, endemicznej rośliny z tyreńskich środkowych Włoch. Klasyfikacja i ordynacja z zastosowaniem metod statystycznych wykazały, że choć *S. etrusca* rośnie głównie w zbiorowiskach z rzędu *Rosmarinetalia* Br.-Bl. ex Molinier 1934, to jednak ekologicznie wiąże się z niestabilnymi, nitrofilnymi zbiorowiskami podlegającymi często zakłóceniom należącymi do rzędu *Helichryso-Santolinetalia* Peinado i Martinez-Parras 1984, o rozmieszczeniu zachodnio--euśródziemnomorskim. Gatunek ten nie posiada dobrze zdefiniowanej pozycji socjologicznej, ponieważ występuje we wszystkich omawianych grupach zbiorowiskowych.

SŁOWA KLUCZOWE: *Santolina etrusca*, syntaksonomia, środkowe Włochy, TWINSPAN, CA.