THE DIVERSITY OF SEGETAL WEEDS IN CRETE (GREECE) AT SPECIES AND COMMUNITY LEVEL

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ABSTRACT - Based on a data set of 74 relevés of cereal fields treated without application of herbicides and fertilizers, the Cretan segetal weed flora and vegetation is analysed. The species pool on the fields comprises almost 20 % of the total flora of Crete although only about 5 % occur more commonly as segetal weeds. While most species occur in a wider range of synanthropic (sub)nitrophytic habitats or semi-natural formations such as phrygana, woodlands and semiwet meadows, a total of 33 species are exclusive weeds of traditional agriculture. The latter include annual species but also a considerable number of geophytes. Several such obligate weed taxa found only in one or few fields are threatened from regional extinction. Two segetal species last recorded 100 years ago have not been confirmed. *Oxalis pes-caprae* is the only alien weed within the last decades that successfully invaded Cretan cereal fields. By means of classification of relevés using floristic criteria 7 plant community types were identified and assigned to three associations (with additional sub-types). Species composition, distribution and ecology of the community types are described and the syntaxonomic and biogeographical relations discussed.

KEY WORDS - Aegean, Cereal fields, Obligate weeds, Segetal plant communities, *Stellarietea mediae*, Traditional agriculture.

INTRODUCTION

Due to irrigation, application of herbicides and fertilizers, and different soil management, segetal weeds of traditional agriculture are vanishing in modern crop systems. As elsewhere in the European Mediterranean, after decades of declining crop farming in Crete, acreage is increasing. However, profitable crops are today olives, green-house vegetables and grapes, not cereals. Studying segetal weed diversity means searching for remnants of traditional rainfed cereal fields. Most terraced fields in Crete are abandoned since 40-50 years or longer, or have been replaced by olive plantations. In the coastal lowlands green-house cultivation is expanding.

Traditional arable farming as defined here is rainfed cereal cultivation without irrigation systems, herbicides and largely without application of non-organic fertil-

izers. In sowing seed corn manually, as is still frequently done, germinating plants and culms are less densely dispersed than with mechanical sowing, leaving space to a variety of winter-annual weeds, especially so near the field margins. Each field is small to medium-sized, i.e., a few ares up to a hectare, often irregular in outline, depending on soil depth and topography. As most such fields are situated on level ground often created by terracing, erosion is insignificant, as opposed to olive and grape plantations newly established on slopes that were clear-cut and then ploughed. Since rainfed cereal farming is not supported by modern agro-economy then why do such fields still exist? The surprising answer is: in support of livestock farming. The colluvial soils are relatively fertile, after all, and the biomass produced exceeds greatly that of abandoned pastures. Oats (*Avena*) and barley (*Hordeum*), also wheet (*Triticum*) and rather exceptionally rye (*Secale*) are sown to be fed to sheep, either directly grazed or else mown, dried, and the hay fed later in the year.

We are not well informed about the diversity of weeds in the past. They are merely included in regional floras and checklists (Rechinger 1943, Barclay 1986, Turland *et al.* 1993, Jahn & Schönfelder 1995). Although Rechinger (1951), in his phytogeographic monograph of the Aegean, devoted it a chapter, the weed flora did not receive particular attention until, more than half a century later, Turland *et al.* (2004) provided detailed notes on the distribution of weeds of traditional agriculture in Crete. Far less known still is the weed vegetation and its ecology. Literature on segetal plant communities in Greece is scarce and far from exhaustive (Oberdorfer 1954, Walther 1969, Lavrentiades 1979, 1980, Ferro 1990). Bergmeier (2005), in a phytosociological study, classified and described plant communities across the ecological and biogeographical range of segetal vegetation in Crete.

The aims of the present paper are to analyse the species diversity and composition of Cretan cereal fields as an example of the vegetation of traditional Mediterranean rainfed agricultural systems, secondly to provide a phytosociological classification of segetal vegetation as a basis for wider geographical comparison. The segetal weeds are grouped according to life form and habitat preferences.

Material and methods

This analysis is based on 74 original relevés sampled on cereal fields throughout Crete and the island of Gavdos south-west off the main island. All fields had been ploughed in the preceding winter and most were sown with winter-annual crops (*Avena sativa*, *Hordeum vulgare*, *Triticum durum*, *Secale cereale*). About 20 % of the relevés originate from fields that were left fallow after ploughing. Selection criteria were:

- not more than one sample per parcel of land or per adjoining parcels;
- fields treated without herbicides and non-organic fertilizers;
- fields remained disregarded, if the invasive *Oxalis pes-caprae* occurred abundantly.

Phytosociological fieldwork was conducted from mid-April to mid-May, with about 70 % of the relevés sampled in 2005, and 30 % in 1995-96 and 1999-2000. Sample plot size was 16-40 m^2 and laid in such a way as to include 1-2 field margins of 2-5 m width. Adjacent parts of the field without soil management were

excluded, as were terrace walls or other non-sown within-field structures. The relevés were sampled with full species lists, cover-abundance values (9-point scale, Dierschke 1994), and environmental and geographical parameters such as crop type and cover, soil characteristics, bedrock, elevation and lat-long co-ordinates. The relevés were edited and classified using TURBOVEG 2 (Hennekens & Schaminée 2001) and JUICE 6.3 (Tichý 2002). TWINSPAN settings were default except for 2 "pseudospecies cut levels" [0, 5]. Two relevés were re-ordered due to their sets of differential species. The resulting synoptic table displays species frequence (constancy) values per community type. For full tables of almost all relevés used here, including location data, see Bergmeier (2005). Plant nomenclature follows basically Jahn & Schönfelder (1995), or else Strid & Tan (2002); for nomenclature of syntaxa see Bergmeier (2005). The map was created using Alan Morton's DMAP.

Results and Discussion

Diversity at species level

The total flora recorded on 74 sample plots in traditionally managed cereal fields comprises 344 species which is slightly less than 20 % of the total flora of Crete. This number includes 7 species of crops which occur both cultivated and as crop relics or weedy as a result of contaminated crop seed. It is remarkable that there is only one alien species that successfully invaded non irrigated agricultural habitats in the last century – *Oxalis pes-caprae*, a noxious weed of South African origin that reached Crete in the 1970s or -80s and which is now fully established not only in man-made but also in a wide range of semi-natural vegetation types.

The regional species pool of segetal fields includes 98 casual species found in only one sample plot. About 40 % (92 species) of the remaining ones are common weed species as they were found in more than 10 % of the sample plots. The most frequently encountered species found in more than one third of all sample plots were (with constancy percentage values in brackets): *Papaver rhoeas* (77), *Lolium rigidum* (70), *Gladiolus italicus* (65), *Scandix pecten-veneris* (64), *Muscari comosum* (64), *Anagallis arvensis* (62), *Chrysanthemum segetum* (57), *Raphanus raphanistrum* (54), *Anthemis altissima* (50), *Silene vulgaris* (49), *Medicago polymorpha* (42), *Vicia sativa* (42), *Ranunculus ficaria* ssp. *chrysocephala* (42), *Rhagadiolus stellatus* (41), *Galium tricornutum* (36), *Silene gallica* (35), *Allium nigrum* (34). This list gives a fairly good impression on the general character of the segetal flora of traditional agriculture although it is likely to be biased as some of the more obvious weeds (*Allium nigrum*, *Gladiolus italicus*) have been used as indicators of traditional field management and may thus be disproportionately represented.

As one would expect in a regularly disturbed habitat the bulk of the weeds consists of short-lived plants, 260 (77 %) of the total number are obligate or facultative therophytes. Bulbous and rhizomatous plants (geophytes) are represented by 21 species (6 %) and the remaining 53 species comprise hemicryptophytes and woody species (mostly seedlings and juveniles of shrubs, subshrubs and trees). The latter group is much more prominent within the low constancy classes (38 species in 1-4 % of the sample plots) and negligible among the frequent weeds (4 species in >10 % of the sample plots) (Fig. 1).

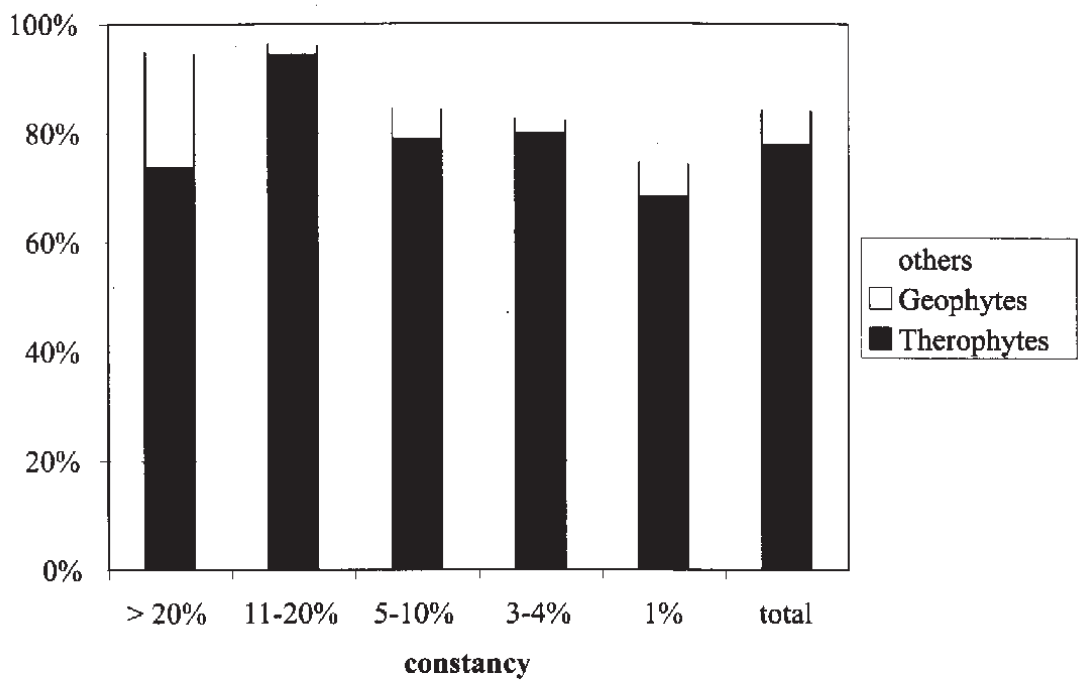

FIGURE 1 - Life form proportions of weeds in segetal fields in Crete across constancy classes.

The situation is quite different with geophytes: more than a third of this group (8 species) was found in >20 % of the sample plots, which equals to 21 % of the more common weed species of traditional agriculture while in all other constancy classes the proportion of geophytes is less than 5 % (Fig. 1).

The origin of the Cretan weeds is a topic already Rechinger (1951) commented on. He distinguished four groups: (1) bulbous and rhizomatous plants considered as remnants of the original vegetation, (2) immigrants from adjacent natural vegetation, (3) immigrants from nitrophytic habitats, (4) introduced (extra-Cretan) plants. As mentioned above there is only one recent introduction (*Oxalis pes-caprae*). More than 50 % of the species encountered in fields of traditional agriculture in Crete (187 species) occur more or less frequently in seminatural vegetation such as rocky pastures, semiwet meadows and woodlands, while 115 species occur in a wide range of human-made, more or less nitrophytic, habitats (Fig. 2). This leaves 33 taxa which are almost exclusive to arable fields with traditional agriculture (Table 1, see also Bergmeier, 2005). A very similar, though slightly shorter list was published by Turland *et al.* (2004). The present list is based on the author's numerous field studies on the flora and vegetation of Crete but the presence or absence of some of the taxa in the list remains nevertheless disputable. Two species of segetal fields in Crete, recorded in the 19th or early 20th century (Rechinger, 1943), *Turgenia latifolia* and *Bupleurum lancifolium*, have not been confirmed since and almost certainly disappeared from the island (Turland *et al.*. 1993). Five other were found during my field studies on only one field leaving them at immediate risk of extinction. The same is true for four species that I found on 1-2 sites on the island of Gavdos but not anymore on Crete.

TABLE 1 - Obligate weeds of traditional (segetal) agriculture in Crete. Life form: T therophyte, G geophyte; Sites in the prefecture Chania: 1 Gavdos, 2 Akrotiri peninsula, 3 Oropedio Krapis, 4 Rodopou peninsula, C other sites; sites in the prefecture Rethimno: 5 Gious Kambos, R other sites; sites in the prefecture Iraklio: 6 Asteroussia, 7 Mesara; sites in the prefecture Lasithi: 8 Lasithi plain, 9 Katharo plain, L other sites; Plant community: SL *Soncho oleracei-Lotetum tetragonolobi*, SC *Sileno gallicae-Chrysanthemetum segetum*, AG *Asperulo arvensis-Gladioletum italici*.

	Life form	Number of records (fields)	Sites	Plant community
Adonis annua ssp. *cupaniana*	T	1	R	SC
Agrostemma githago	T	12	2,4,9,C,R	AG, SC, SL
Allium nigrum	G	25	1,2,3,4,8,9,C,L,R	AG, SC, SL
Allium trifoliatum	G	14	1,2,4,6,8,C,L	AG, SC, SL
Alopecurus myosuroides	T	3	2,6,C	SC, SL
Anthemis altissima	T	37	2,3,4,5,6,7,8,9,C,R	AG, SC
Asperula arvensis	T	8	8,9	AG, SC
Bifora testiculata	T	14	1,4,5,8,9,C,R,L	AG, SC, SL
Centaurea cyanus	T	2	C,R	SC
Cerastium dichotomum	T	4	9	AG
Chrysanthemum segetum	T	41	2,3,4,5,6,8	AG, SC, SL
Consolida ajacis	T	1	4	SC
Galium tricornutum	T	27	2,3,4,5,6,8,9,C,L,R	AG, SC, SL
Galium verrucosum	T	4	1,2,R	SC, SL
Geranium tuberosum	G	1	8	AG
Leontice leontopetalum	G	5	7,9,R	AG, SC, SL
Linaria chalepensis	T	3	1,2,6	SC, SL
Linaria micrantha	T	1	1	SL
Linaria triphylla	T	2	1	SL
Lithospermum arvense	T	17	1,8,9	AG, SL
Lolium subulatum	T	4	1	SL
Lolium temulentum	T	11	1,2,3,5,C,R	SC, SL
Neslia apiculata	T	8	4,9	AG, SC
Ornithogalum nutans	G	7	8,9	AG, SC
Papaver apulum	T	11	3,4,5,6,R	SC, SL
Papaver hybridum	T	19	1,4,5,6,C,L,R	SC, SL
Ranunculus arvensis	T	13	4,5,8,9	AG, SC
Ranunculus asiaticus var. *sanguineus*	G	4	1,4,C	SC, SL
Raphanus raphanistrum	T	39	1,2,3,4,5,6,8,9,C,L,R	AG, SC, SL
Roemeria hybrida	T	1	1	SL
Tulipa doerfleri	G	3	5,R	SC
Vaccaria hispanica	T	3	9	AG
Veronica triloba	T	8	6,8,9,C	AG, SC

The proportion of exclusive weeds of traditional agriculture among the total number of weeds is about 10 %, and so is the proportion of therophytes in both groups. The proportion of geophytes that are obligate weeds of traditional agriculture, however, is one third (7 out of 21) of the total number of geophytes found in cereal fields.

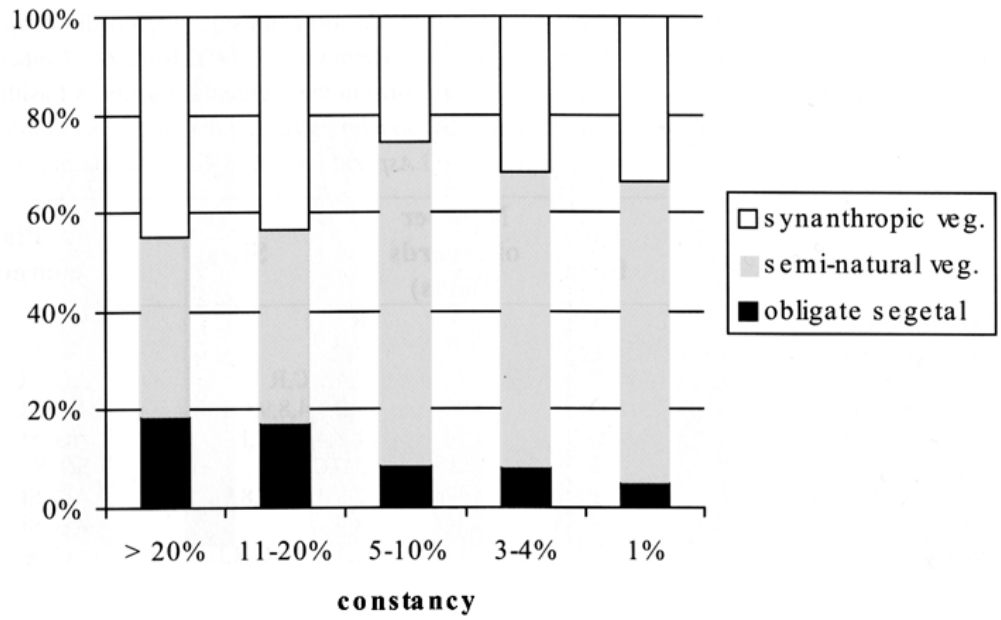

FIGURE 2 - Habitat preferences of weeds occurring in segetal fields in Crete across constancy classes.

Obligate segetal weeds are present in all community classes but with higher proportions among the more frequently encountered species (>10 % constancy). The proportion of weeds occurring in a wider range of synanthropic habitats is slightly higher in higher constancy classes than in lower, while weeds that occur moreover in semi-natural habitats are more frequent among the lower constancy classes than among the higher (Fig. 2). Vierhapper (1916: 128, cited in Rechinger 1951: 194) provided a list of 111 species of plants of segetal fields combining observations from two agricultural areas in Crete. It includes 14 obligate segetal weeds of which 13 are still present on Crete, 43 species of semi-natural habitats, and 52 ruderal species of synanthropic habitats.

Diversity at community level

The classification revealed seven interpretable plant community types which are presented in a synoptic table (Table 2). The distribution of community records is displayed in Fig. 3. Differential species are highlighted in the table. They are defined as occurring with high constancy values in one or more community types while missing or with less than half the constancy values in others.

A) *Soncho oleracei-Lotetum tetragonolobi chrysanthemetosum coronarii*
(Table 2, community type 1)
DISTRIBUTION: thermo-Mediterranean zone, restricted to the island of Gavdos and a few sites in the coastal lowlands of northern Crete (Fig. 3).
ECOLOGY: on rather fertile marls and flysch in dry locations. Gavdos is among the most arid places in the south Aegean.
COMMUNITY STATISTICS: by far the highest number of species per relevé and the highest of constant species among all community types. The latter is probably due to the fact that most records are from one restricted area (Gavdos).

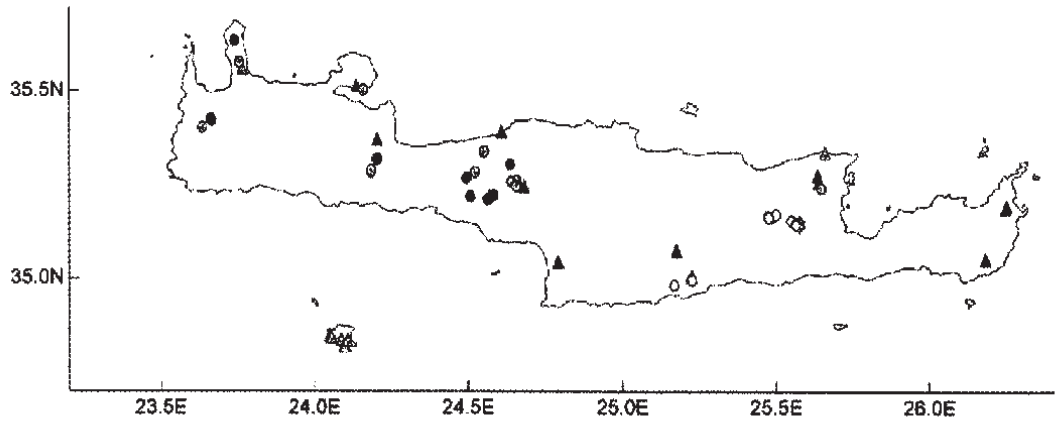

FIGURE 3 - Distribution of segetal weed communities in Crete based on original relevés. Triangle: *Soncho oleracei-Lotetum tetragonolobi*, grey: *chrysanthemetosum coronarii*, black: typicum; circle: Sileno *gallicae-Chrysanthemetum segetum*, grey: *rumicetosum bucephalophori*, black: typicum, white: *senecionetosum vulgaris*; diamond: *Asperulo arvensis-Gladioletum italici*.

B) *Soncho oleracei-Lotetum tetragonolobi typicum*
(Table 2, community type 2)
DISTRIBUTION: thermo-Mediterranean zone, in all parts of Crete but restricted to moderately low locations (Fig. 3).
ECOLOGY: base-rich soils, often red, silty, well-aerated, from colluvial material derived from various types of limestone.
COMMUNITY STATISTICS: The low number of constant species (15) in relation to the mean number of species per relevé (31) suggests a rather low degree of homogeneity within the set of relevés available. The fact that most fields are rather isolated from each other may contribute to this effect.

C) *Sileno gallicae-Chrysanthemetum segetum rumicetosum bucephalophori*
(Table 2, community types 3 and 4)
SUBTYPES: (a) variety with *Anthemis arvensis*; (b) variety with *Ranunculus sardous*. Nutrient-demanding species that are common in other communities, such as *Medicago polymorpha*, *Rhagadiolus stellatus* and *Scandix pecten-veneris* are missing in var. (a); species indicating poorly aerated soil (*Ranunculus sardous*, *Oenanthe pimpinelloides*) are prominent in var. (b).
DISTRIBUTION: meso-Mediterranean zone: scattered in western and west central Crete, recorded between 350 and 800 m (Fig. 3).
ECOLOGY: light acid soils, mostly sandy, at low fertility level, derived from quartzitic bedrock (much of var. with *Anthemis arvensis*), or deep silty base-impoverished colluvial soils from limestone (much of var. with *Ranunculus sardous*).
COMMUNITY STATISTICS: Species diversity is somewhat lower than in the other subassociations (D., see below) which may be due to environmental restrictions such as limited nutrient supply.

TABLE 2 - Synoptic table of the plant community types in cereal fields of Crete. Percentage frequency values (constancy) are given per community type. 1-2 *Soncho oleracei-Lotetum tetragonolobi*, 1 subass. *chrysanthemetosum coronarii*, 2 subass. typicum, 3-6 *Sileno gallicae-Chrysanthemetum segetum*, 3-4 subass. *rumicetosum bucephalophori*, 3 var. with *Anthemis arvensis*, 4 var. with *Ranunculus sardous*, 5 subass. typicum, 6 subass. *senecionetosum vulgaris*, 7 *Asperulo arvensis-Gladioletum italici*. The table is shortened by species of constancy values below 35 % in all columns and by crop species.

Community type no.	1	2	3	4	5	6	7
No. of relevés	11	12	6	11	15	9	10
Mean no. of species per relevé	43	31	26	29	34	32	25
No. of constant species (≥ 35 %)	54	15	20	29	21	32	27
Plantago afra	73	42	.	.	.	.	.
Lotus tetragonolobus	36	58	.	.	27	.	.
Chrysanthemum coronarium	91	33	.	.	13	11	.
Plantago lagopus	82	33	33	.	13	.	.
Hypochaeris achyrophorus	55	.	.	.	.	.	.
Silene nocturna	64	8	.	.	7	.	.
Trifolium scabrum	45	.	.	.	.	.	.
Biscutella didyma	73	17	.	.	7	11	.
Tordylium apulum	73	17	.	.	13	.	.
Sonchus oleraceus	73	33	.	.	7	.	.
Carduncellus caeruleus	45	8	.	.	.	.	.
Scorpiurus muricatus	45	8	.	.	.	.	.
Trifolium tomentosum	73	8	33	9	27	.	.
Coronilla scorpioides	45	8	.	18	.	.	.
Urospermum picroides	45	17	.	.	7	.	.
Phalaris minor	64	8	17	18	20	11	.
Papaver hybridum	73	25	17	9	27	22	.
Bromus alopecuros s. str.	45	17	.	.	13	.	.
Filago pyramidata	55	17	.	.	20	11	10
Hordeum leporinum	45	8	17	.	20	.	.
Filago contracta	36	.	.	.	.	.	.
Bromus rubens	36	.	.	.	.	.	.
Astragalus hamosus	36	.	.	.	.	.	.
Lolium subulatum	36	.	.	.	.	.	.
Didesmus aegyptius	36	.	.	.	.	.	.
Valantia hispida	36	.	.	.	.	.	.
Medicago monspeliaca	36	.	.	.	.	.	10
Hymenocarpos circinnatus	36	8	.	.	.	.	.
Medicago truncatula	36	8	.	.	.	.	10
Oxalis pes-caprae	.	58	.	9	20	11	.
Hypericum triquetrifolium	.	50	.	9	27	.	.
Chrysanthemum segetum	18	25	100	91	93	78	.
Raphanus raphanistrum	18	25	100	91	67	78	20
Cerastium glomeratum	.	.	50	55	27	56	10
Silene gallica	.	25	100	82	40	22	.
Rumex bucephalophorus ssp. *bucephalophorus*	.	.	100	73	.	11	.
Lotus angustissimus	.	.	67	.	.	.	.
Tolpis barbata	.	.	67	.	.	.	.
Anthemis arvensis ssp. *incrassata*	.	.	100	27	7	.	50
Trifolium glomeratum	.	.	50	.	7	.	.
Trifolium arvense	.	.	50	9	.	.	.
Vulpia ciliata	9	.	50	9	.	.	.
Crepis zacintha	.	.	50	9	7	.	.
Linaria pelisseriana	.	.	67	18	13	11	.
Poa bulbosa s.l.	.	.	50	9	.	.	20
Sagina apetala	.	.	50	18	7	.	.
Oenanthe pimpinelloides	.	.	.	45	7	.	.
Ranunculus sardous	.	.	.	55	27	11	.
Lolium temulentum	18	8	17	55	7	.	.
Cynosurus echinatus	.	.	17	36	7	.	10
Poa trivialis ssp. *sylvicola*	.	.	.	27	47	.	.
Anchusa hybrida	.	.	.	.	7	67	10
Veronica triloba	.	.	.	.	7	67	10
Filago pygmaea	.	.	.	.	.	44	.

Fumaria officinalis	.	.	.	.	7	44	.
Aphanes arvensis	.	.	.	18	.	44	.
Senecio vulgaris	36	8	.	.	.	56	.
Legousia hybrida	9	8	.	.	13	56	10
Erophila verna	.	.	.	.	.	56	60
Ranunculus arvensis	.	.	17	18	13	44	40
Ornithogalum nutans	.	.	.	.	.	44	30
Cardaria draba	.	.	.	.	.	33	50
Convolvulus arvensis	.	.	.	9	7	44	20
Vicia tenuifolia ssp. *dalmatica*	.	.	.	.	.	.	70
Neslia apiculata	.	.	.	.	7	.	70
Asperula arvensis	.	.	.	.	.	22	60
Cerastium dichotomum	.	.	.	.	.	.	40
Bunium ferulaceum	.	33	.	27	13	22	70
Anthemis chia	9	8	.	.	.	11	40
Eryngium campestre	18	25	17	9	13	33	60
Rostraria cristata	64	.	.	18	33	11	.
Sinapis arvensis	73	25	.	45	13	22	20
Catapodium rigidum	82	8	.	18	33	56	10
Ornithogalum narbonense	82	25	17	9	20	.	50
Lithospermum arvense	64	.	.	.	.	33	70
Allium trifoliatum	45	25	.	.	7	56	.
Trifolium campestre	55	8	50	18	27	.	.
Bromus madritensis	45	17	17	.	27	.	.
Calendula arvensis	36	25	.	.	33	33	.
Medicago rugosa	36	8	.	.	20	.	10
Torilis nodosa	36	17	17		27		
Trifolium stellatum	36	8	17		13		
Crepis commutata	18	33	.	18	40	.	.
Rumex pulcher s.l.	36	8	33	36	53	11	.
Hedypnois cretica	9	33	33	36	33	.	.
Crepis vesicaria	.	33	33	36	33	.	.
Hirschfeldia incana	9	33	33	27	60	11	.
Allium nigrum	9	42	.	.	60	11	90
Anthemis altissima	.	33	17	82	67	100	40
Galium tricornutum	.	33	.	36	47	44	80
Ranunculus ficaria ssp. *chrysocephala*	27	8	.	55	33	89	80
Vicia lutea	.	17	.	55	33	22	10
Ranunculus paludosus	.	8	33	55	27	33	70
Lamium amplexicaule	9	42	.	9	27	78	20
Sherardia arvensis	.	33	17	.	40	67	.
Capsella bursa-pastoris	.	17	.	.	7	56	30
Galium murale	9	33	.	9	20	44	.
Lathyrus aphaca	9	.	.	36	7	11	20
Lathyrus cicera	27	.	.	.	.	44	10
Papaver apulum	.	8	33	36	13	22	.
Muscari comosum	91	42	17	73	60	44	100
Gladiolus italicus	91	50	17	55	67	56	100
Scandix pecten-veneris	82	50	.	45	87	67	80
Medicago polymorpha	64	58	.	18	67	44	10
Rapistrum rugosum	9	42	33	36	33	.	50
Vicia sativa	45	25	.	64	40	44	60
Rhagadiolus stellatus	55	33	.	18	53	56	50
Anemone coronaria	45	25	.	.	27	33	30
Silene vulgaris ssp. *macrocarpa*	82	42	67	36	40	33	50
Lolium rigidum s.l.	64	75	83	73	80	67	50
Anagallis arvensis	82	83	83	73	73	33	.
Papaver rhoeas	82	58	67	64	93	100	70

D) *Sileno gallicae-Chrysanthemetum segetum typicum*
(Table 2, community type 5)

DISTRIBUTION: meso-Mediterranean zone, most common segetal community of traditional agriculture in the Cretan arable mountain plains ('*oropedio*') such as Askifou and Krapis; occurring in west and central Crete but not found in the east, from the lowlands where it is rare to locations above 600 m (Fig. 3).

ECOLOGY: colluvial brown soils derived from hard limestone; the lack of specific differential species indicates medium environmental conditions.
COMMUNITY STATISTICS: higher number of species per relevé than in the other two subassociations.

E) *Sileno gallicae-Chrysanthemetum segetum senecionetosum vulgaris*
(Table 2, community type 6)
DISTRIBUTION: upper meso-Mediterranean zone, found from 585-850 m, in the Lasithi plain in east central Crete, and the Asterousia mountains in south central Crete (Fig. 3). (As opposed to Bergmeier, 2005, the Lasithi relevés were assembled here instead of forming a variety of the *Asperulo-Gladioletum*.)
ECOLOGY: brown soils derived from base-rich flysch and weathered Tripolitsa limestone.
COMMUNITY STATISTICS: as in the previous subassociation relatively high number of species per relevé but also high number of constant species indicating homogeneity probably due to the limited distribution.

F) *Asperulo arvensis-Gladioletum italici*
(Table 2, community type 7)
DISTRIBUTION: upper meso-Mediterranean zone, restricted to the Katharo plain situated at 1100-1200 m, in the Dikti massif (east central Crete) (Fig. 3).
ECOLOGY: The Katharo plain is an extensive mountain plain and the highest currently cultivated *oropedio* in Crete. It is rather isolated which may add to the floristic distinctness of the segetal community. The deep fairly base-rich colluvial soils developed from the Tripolitsa limestone of the surrounding mountains. The local climate is pronouncedly cool and relatively humid.
COMMUNITY STATISTICS: In spite of the ecological borderline situtation and the limited geographical distribution species numbers per relevé and number of constant species are at medium levels.

Biogeography and syntaxonomy

The plant communities of winter-annual cereal fields in Crete and Gavdos have been identified and described by Bergmeier (2005). With the following annotations the three associations distinguished above are put into a wider biogeographic frame.

Soncho oleracei-Lotetum tetragonolobi. The high proportion of non-exclusive weeds that occur otherwise along roadsides and in patches of subnitrophytic ephemeral communities on pastures suggest to relate this community type with the order *Thero-Brometalia*. It is remarkable that *Thero-Brometalia*, though widespread in the Mediterranean, represents segetal vegetation only in the southernmost European parts of the Mediterranean and in North Africa, not further north. Since the *Soncho-Lotetum* has many species in common with its Andalusian counterpart, the *Tetragonolobo-Fedietum* (see Rivas-Martinez *et al.*. 2001, 2002, Nezadal 1989), it has been suggested to assemble the Cretan association in the same alliance *Cerintho majoris-Fedion cornucopiae* (Bergmeier, 2005).

Sileno gallicae-Chrysanthemetum segetum. This association is widely circumscribed and includes all segetal communities of meso-Mediterranean Crete except for the Katharo plain. Species composition is acidophytic and resembles *Aperetalia spicae-venti* communities reaching the meso-Mediterranean zone in the Iberian peninsula. While Rivas-Martinez (2001, 2002) treated them within the widespread atlantic

alliance *Scleranthion annui*, Nezadal (1989) split those from the southern half of Spain, and coined the *Rumicion bucephalophori*. The latter concept is followed here, since the *Sileno gallicae-Chrysanthemetum* and in particular its subassociation *rumicetosum* has many species in common with that alliance. The frequency of species indicating poorly aerated soils (*Lotus angustissimus*, *Ranunculus sardous*, *Oenanthe pimpinelloides*, *Crepis vesicaria*) parallels with the Iberian syntaxon.

Asperulo arvensis-Gladioletum italici. This association occurs very locally in Crete. It represents the basiphytic order *Centaureetalia cyani* which is distributed from Central Europe through the meso-Mediterranean zone (Bergmeier, 2005). Diagnostic species of the order found in the *Asperulo-Gladioletum* include *Asperula arvensis*, *Lithospermum arvense*, *Galium tricornutum*, *Neslia apiculata*, *Ranunculus arvensis* and *Scandix pecten-veneris*. The species composition (with *Bifora testiculata* and *Cerastium dichotomum*) resembles the alliance *Roemerion hybridae* although the relationship to western and central Mediterranean counterparts does not seem to be very pronounced.

As a conclusion the following syntaxonomic scheme has been suggested (Bergmeier 2005, nomenclatural references of higher syntaxa not verified):

Stellarietea mediae R. Tx. *et al.*. ex von Rochow 1951

Aperetalia spicae-venti J. et R. Tx. in Malato-Beliz *et al.*. 1960

Rumicion bucephalophori Nezadal 1989

Sileno gallicae-Chrysanthemetum segetum Bergmeier 2005, Hoppea 66: 362

Thero-Brometalia (Rivas-Goday & Rivas-Martinez ex Esteve 1973) O. Bolòs 1975

Cerintho majoris-Fedion cornucopiae Rivas-Martinez & Izco ex Peinada *et al.*. 1986

Soncho oleracei-Lotetum tetragonolobi Bergmeier 2005, Hoppea 66: 359

Centaureetalia cyani R. Tx. ex von Rochow 1951

Roemerion hybridae Br.-Bl. ex Rivas-Martinez *et al.*. 1999

Asperulo arvensis-Gladioletum italici Bergmeier 2005, Hoppea 66: 367

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