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Botanical Survey of Floral Species and Animal Feeding Values in Pasturelands of Environments with a Mediterranean Climate

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ABSTRACT

The native flora of Mediterranean environments with meso-Mediterranean zones, instead of being protected by European Union and Italian government law, continue to be threatened as a result of the effect of social and anthropological evolution and misleading utilization of herbs causing genetic erosion of flora species. A floral survey was established over a three-year period in 20 pasturelands. The biodiversity discovered in the environmental pastures amounts to 29 botanical families and 361 floral species. The most represented floral species (expressed as a percentage of the mean value of the floral species of pasturelands) belong to the following botanical families: Graminaceae (26%), Leguminosae (17%), Compositae (19%), Labiatae (5%), Liliaceae (5%), Umbelliferae (3%), Cruciferae (4%), Plantaginaceae and Ranunculaceae (3%), and Caryophyllaceae (2%). The floral species less represented (< 1% of total flora) are included in a miscellaneous group composed of 19 botanical families. The floral biodiversity influences the herbage and milk feeding units of pasturelands. Five species from the Graminaceae (*Aegilops geniculata* L., *Dasypyrum villosum* (L.) Borbas, *Stipa barbata* Desf., *Lolium perenne* L. and *Phalaris minor* L.), which face the risk of extinction, were evaluated over a separate (but later) two-year period at Foggia for seed production. Agronomic evaluations of seed yield and its components of the five most popular grass species evidenced different bioagronomic characteristics and the possibility to provide a seed source for reseeding degraded pasturelands as a way to recover the natural equilibrium of native species in Mediterranean environments. Agronomic practices for seed production of floral species under the risk of extinction in favourable environments in order to provide seed stock to reseed represent a scientific tool to reduce the genetic erosion of floral species present in the degraded swards of the Mediterranean pasturelands.

Keywords: botanical composition, flora species survey, Mediterranean environments, nutritive feeding value of herbs, sward of dry matter production

INTRODUCTION

Rich floral biodiversity exists in areas with bioclimatic meso-Mediterranean zones ensuring a characteristic landscape, ecologic function of its environments and animal feeding production for supporting livestock and shepherd activity (Plantureux *et al*. 2004; Martiniello 2008; Mounir *et al*. 2009; Brunel *et al*. 2010; Tastad *et al*. 2010). A survey of botanical composition represents a scientific means with paramount interest that would allow technical information on livestock grazing to be useful for maintaining floral species biodiversity in a pasture surface covered by turf, defined as sward structure by Sanderson *et al*. (2006). There is a sward of pasturelands of environments in the European Union (EU) with meso-Mediterranean weather characteristics, especially in Districts of southern Italy (10.874 million ha) (Boitani *et al*. 2002; Abdelguerfi *et al*. 2004; Boussaid *et al*. 2004; Martiniello and Berardo 2007; Maxted *et al*. 2007). The herbage produced from these areas is mainly used for grazing (cows, sheep, goats, buffaloes, horses, donkeys and wild pigs), which make up 57% of the total Italian livestock (ISTAT 2010).

The native floral biodiversity of these areas is protected against the introduction of exotic germplasm by an EU Directive (1992), an Italian legislative Decree (1991) and EU Decision (2010).

Instead of respecting the law and pasture environments, and in order to satisfy the demands of livestock gross products or the curiosity of amateur tourists, shepherds and visitors in general do not care for the flora in these pastures nor are there appropriate agropastoral management practices that respect the rhythms of floral development other than economic interest or curiosity (Thuiller *et al*. 2004; Undervood *et al*. 2009). Thus, unfortunately, in the past decade, biodiversity of the native flora of these environments, due to neglected utilization of these pasturelands, has strongly changed in favour of herbs with low feeding value (Crespo 1985; Abdelguerfi and Abdelguerfi-Laouar 2004; Boussaid *et al*. 2004; Martiniello 2008). The consequences of grasslands utilization linked to economic exploitation without care of the ecophysiology and dynamics of grass development of native floral biodiversity has induced botanical changes in pastureland swards of Mediterranean environments (Lemaire 2001; Martiniello and Berardo 2007; Sanderson *et al*. 2006).

Farmers who increase the herbage feeding demand for animal or livestock breeding do not adopt appropriate grazing management practices. This stress induces reduction of sward herbage production and variation in botanical composition and herbage development of the existing floral species. The effect of intensive grazing has allowed the ecological equilibrium to be altered with a consequent stress of flora in the sward and selection of herbage desired by grazing animals (Perovolotski and Seligman 1998; Abdelkefi and Marrakchi 2000; Bounejmate *et al*. 2004 Plantureux *et al*. 2004; Mounir *et al*. 2009; Sepe *et al*. 2011). The effect of sheep grazing on pasturelands at different stocking rates differently influenced yield potential, feeding value and flora composition of herbage. The sward of pasture grazed with animals at a high stocking rate (4.0 LU ha^{-1}) in comparison to those with low stocking rates (1.0 and 0.2 LU ha^{-1}), strongly affected the dry matter (DM) production, the

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quality of herbage grazed and the floral species in the phytocoenoses of the sward. Grazing pastureland at a high stocking rate e.g. 4.0 LU ha^{-1} determined overgrazing and induced variation in the ecophysiology of the grassland with a consequent variation of flora composition of sward characterized to have grass species not preferred by animals and herbage with coarse, rough, woody and thorny morphological organs which had low desirability to be grazed by animals, specifically *Centaurea* spp., *Cirsium* spp., *Asphodelus* spp., *Cichorium* spp., *Euphorbia* spp., and *Galium* spp. The effect of overgrazing of pasturelands allows selection among flora within the sward and degradation of the pasture with a consequent reduction in herbage production and nutritive feeding value (MFU) of the undisturbed biomass determined in swards protected from animal grazing by cages (Talamucci *et al*. 1987; Martiniello and Berardo 2004, 2007; Martiniello 2008; Casagrande *et al*. 2011).

The failure of a natural ecologic equilibrium of an ecosystem favours, initially, genetic drift, and subsequently, extinction of the natural flora (Abdelkefi and Marrakchi 2000; Plantureux *et al*. 2005; Mounir *et al*. 2009; Brunel *et al*. 2010; Tastad *et al*. 2010). However, the use of appropriate agronomical practices (chemical enrichment of soil and reseeding) for a period of 6 years has been suggested as a means to favour germination of indigenous seed present in the sward thus favouring the development of native flora and recovering the ecological equilibrium endowed in natural EU pastures (Pérez *et al*. 1988; Nie *et al*. 1999; Iannucci *et al*. 2005; Martiniello and Berardo 2007).

The recovery of natural floral composition of swards and the ecological function of environments is mainly linked to the development of shepherd livestock management techniques that are able to restore natural biodiversity and sustainability of landscape characteristics of those environments (Perevolotsky and Seligman 1998; Bounejmate *et al*. 2004; Turner 2004; Plantureur *et al*. 2005; Martiniello 2008). The ecological function and landscape protection of pasturelands is in stark contrast with the economic profit of these environments that use agropastoral and resort activities. A conflict arises between the physiological aspects of phenological floral development and economic exploitation of pasturelands, which may enlarge the red list of threatened species in a sward of the Mediterranean basin (Thuiller *et al*. 2004; Underwood *et al*. 2009). Thus, maintenance of the threatened floral biodiversity in pasturelands by agronomic practices able to reproduce seeds of flora in favourable environments by reseeding the ecosystem may be considered as a useful scientific approach for reducing the damage favoured by climatic change and negligent agropastoral use of the natural ecosystems (Turner 2004; Plantureur *et al*. 2005; Maxted *et a*l. 2007; Tastad *et al*. 2010).

The agronomic feasibility of reproducing seed of the vulnerable flora to be used as reseeding in pasturelands to recover an ancient equilibrium may represent a scientific effort to sustain the floral biodiversity in the sward (Martiniello 2008; Mounir *et al*. 2009; Tastad *et al*. 2010).

The aims of these experiments were, in meso-Mediterranean natural environments: 1) to survey the floral composition of pasture swards, 2) to assess the botanical biomass and chemical composition and animal feeding values of herbage, 3) to assess the effect of sheep grazing with three stocking rates on DM production, MFU and flora composition of the herbage and 4) to evaluate the possibility of reproducing seed of targeted floral species by an agronomic approach for reseeding a sward with autochthonous germplasm.

MATERIALS AND METHODS

Geographical settlement of pasturelands

The experiments were established during 1997 to 1999 to survey the floral species in 20 pasturelands scattered over an area located in the range of geographical coordinate: 15° 14′ to 16° 26′ longitude East and 46° 46′ to 41° 51′ latitude North and an altitude of 76-905 m above sea level. The location of pastures where the experiment was established will be referred to using experimental pasture codes (**Table 1**) in the text, figure and tables.

Table 1 Geographical coordinate and soil chemical and annual aridity index characteristics of the pastures studied.

Pasturelands code[a]	**Coordinate geographic of pastureland**			**Soil chemical and de Martonne aridity index characteristics**						**Rainfall**[m]	**Aridity index**[n]
	Longitude East[b]	**Latitude North**[c]	**Altitude**[a]	**pH**[e]	**Organic matter**[f]	**Total nitrogen**[g]	**Available P**[h]	**Exchangeable K**[i]	**Mean T**[l]		
Code 1	15°14’	41°18’	905	7.3	9.3	0.58	11	867	10.3	715	36
Code 2	15°17’	41°11’	847	7.5	4.8	0.31	9	811	13.9	781	33
Code 3	15°24’	41°13’	514	7.6	6.2	0.29	4	723	11.5	635	30
Code 4	15°18’	41°41’	838	7.0	5.4	0.32	4	463	15.6	797	31
Code 5	15°52’	41°51’	150	7.3	9.8	0.51	19	190	15.8	491	19
Code 6	15°38’	41°42’	87	7.0	8.9	0.46	5	956	15.6	482	19
Code 7	15°34’	41°40’	57	7.4	5.8	0.32	6	1007	14.9	599	24
Code 8	15°36’	41°15’	410	7.8	6.5	0.36	16	1365	15.9	535	21
Code 9	15°39’	41°20’	124	7.9	5.6	0.34	5	719	13.9	407	17
Code 10	15°25’	41°36’	514	7.9	6.6	0.52	7	665	13.9	407	17
Code 11	15°35’	41°27’	76	7.6	5.0	0.25	23	1342	15.1	487	19
Code 12	15°10’	41°49’	135	7.5	11.5	0.66	22	617	16.5	446	17
Code 13	15°09’	41°35’	251	7.7	7.8	0.36	29	1370	15.7	815	32
Code 14	15°16’	41°10’	514	6.7	7.4	0.48	26	1096	15.7	632	25
Code 15	16°19’	40°51’	350	7.6	10.1	0.58	25	764	15.2	438	17
Code 16	16°26’	40°46’	356	7.8	10.1	0.53	35	852	15.8	586	19
Code 17	15°45’	41°38’	57	7.9	4.4	0.22	9	698	15.4	531	21
Code 18	15°52’	41°40’	59	7.1	11.5	0.32	29	893	11.1	543	26
Code 19	16°17’	41°09’	156	7.4	8.2	0.44	3	637	15.6	483	19
Code 20	15°49’	41°42’	557	7.5	11.1	0.66	22	617	11.3	548	26

[a] Identification code of experimental pastureland
[b] and [c] pastureland geographic position longitude and latitude, respectively from zero-longitude meridian of Greenwich Royal Observatory
[d] m above see level
[e] n
[f and g] g/100 g
[h] and [i] mg/g
[l] °C
[m] yearly mm of water
[n] n

Meteorological characteristics

The pattern of meteorological parameters, yearly mean of temperatures, rainfall and de Martonne (1926) aridity index that typified the sites of experimental pastures were those reported in the UNESCO-FAO (1963) meso-Mediterranean bioclimatic map of Mediterranean environments (**Table 1**).

Soil determination

Four soil samples from the 0-30 cm Ap horizon were used for determining chemical characteristics of topsoil at the end of the floral survey from each experimental pasture (**Table 1**). The samples were mechanically removed by a metal core spiral 60-mm in diameter, sieved to separate roots, air-dried, passed thought a mesh screen with 2 mm Ø and then stored at room temperature until laboratory analysis. The chemical traits determined were: pH (potentiometrically with a glass electrode using a 1: 2.5 soil: water ratio) (Day 1965), total nitrogen (Kjeldahl 1983), organic matter (Walkey and Black 1934), available phosphorous (Olsen *et al.* 1954) and exchangeable potassium (UNICHIM 1985).

Establishment of pasture experiments

The experimental pastures during the period of evaluation (2009 to 2011) were grazed throughout all months of the year. A pasture area of about 1000 m^2 was protected by an electric fence. In November, within the experimental area, to prevent grazing of biomass, manufactured iron smith parallel piped cages (150 cm long, 150 cm wide and 100 cm in height) were implanted and completed with a poultry and rabbit Bekaert welded wire-still fence (**Fig. 1**). For each year of evaluation, the biomass developed in the cage was used for classification of floral species and determination of animal feeding. The total cages set up for each experimental pasture surface were height. There were four replications used floral classification and as many as for biomass evaluation. The cage of each replication used for floral classification and the cages used for biomass evaluation were closely allocated at a tandem. The 1 m^{-2} of undisturbed herbage of each pair of cages (tandem), at flowering of grass species, was manually moved to about 10 cm above ground level. The neighbouring harvests reduced or minimize the effect of toposoil on development of biomass samples used for determining floral composition and quantitative and qualitative characteristics of the sward, the cages of each repetition were allocated as neighbours. Thus, the biomass harvested in a cage used for yield and qualitative determination and that harvested in a neighbouring cage for botanical determination presents a reduced effect of the influence of soil on the development of a grassland and, as a consequence, reduced variation in yield and quality of herbage characteristics and floral composition.

Establishment of stocking rates experiment

On pastureland located in Foggia, three areas of pastures, each with 1.0 ha surface, were electrically fenced. The herbage of each pasture surface was grazed by 2, 6 and 24 sheep (Sardinian landrace) equivalent to stocking rates of about 0.2, 1.0 and 4.0 LU ha^{-1}. LU ha^{-1} is an English term, defined by Andrews and Rebane (1994), which defined the amount of forage needed to sustain an adult, non-pregnant cow or 6 medium size sheep, with about 400 kg of living body weight. On each pasture surface at random eight cages were allocated and disposed at tandem for a total of 4 replications. The undisturbed biomass of 4 tandem cages was harvested at entrance of the sheep pasture and used for determination of DM and MFU traits while the biomass of the other four cages was used for floral species determination.

The entrance and exit of animals to grazing were based on the development of turf. The grazing of pasture benign herbage started and finished when floral plant height was 25 and ~ 10 cm tall, respectively. At the time of entrance, 1 m^2 biomass of flora of one tandem cage was manually harvest, dried until when the herbage reached approx. 30% moisture (after about one week) in an air chamber at 35°C until botanical sieving while the biomass harvest from the other 1 m^2 cage was weighed and a sample of about 500 g dried at 60°C for 72 h, weighed for DM determination and thereafter, milled for preparing flour for chemical analyses.

Fig. 1 Experimental cage. The inside undisturbed biomass was used for flora species botanical composition and qualitative and quantitative characteristics of the sward.

Flora and biomass characteristics

In each year of evaluation, floral composition, biomass production, moisture at harvest, and MFU of the herbage were assessed at the flowering stage of grass development. In this phonological stage of grasslands, the physiological process reaches an apex of activity for storing biochemical compounds in the organs of plants and the optimum morphological development of flowering structures for floral botanical classification (Iannucci *et al*. 1996; Martiniello *et al*. 2011). Harvest generally took place in the last week of May by mowing, manually from the ground level, as 1 m^2 biomass under the cage (**Fig. 1**). The grazing time of pasturelands was scheduled according to the livestock's characteristics based on plant height during grass development.

The 1 m^2 harvested herbage biomass used for botanical classification during mowing was held in small bunches tied with an elastic rubber and dried in a double ventilation air chamber at 35°C (room temperature) until sieving. The floral species of the harvested biomass were classified according to Fiori (1969) and Pignatti (1982) botanical guides. At the end of the classification, the flora was transferred into a ventilated room chamber at 60°C for 72 h, weighed and then grouped into botanical families: Graminaceae, Leguminosae, Compositae, Labiatae, Caryophyllaceae, Cruciferae, Liliaceae, Rubiaceae, Plantaginaceae and Umbelliferae. Floral species with less than 1% of the total (DM) were included in a miscellaneous group composed by floral species belonging to the following botanical families: Amaranthaceae, Borraginaceae, Campanulaceae, Chenopodiaceae, Convolvulaceae, Dipsaceae, Euphorbiaceae, Filicies, Geraniaceae, Iridaceae, Malvaceae, Orchidaceae, Orobanchaceae, Papaveraceae, Polygonaceae, Primulaceae, Ranunculaceae, Scrophulariaceae and Verbanaceae. On the basis of DM weight of floral species and botanical family, the percentage of DM contributing to total herbage was determined.

The biomass production and qualitative characteristics were assessed by weighing the biomass of 1 m^2, moved manually, and at random, a sample of about 500 g was oven-dried (60°C for 72 h) to determine moisture. At the end of both harvests, the remnant above-ground biomass was cut out and removed from the cage. The DM used for moisture determination was ground with a Cyclotec mill with a 1 mm Ø mesh screen and stored at room temperature until laboratory analysis. The chemical determinations of qualitative characteristics were performed by standard procedures: crude protein [CP, Dumas method as modified by Kirsten (1963)], crude fibre (CF, Henneberg and Stohmann (1984) known as Weende method) and neutral-detergent fibre (NDF), acid-detergent fibre (NDF) and acid-detergent lignin (ADL) by Goering and van Soest (1970). The MFU of the herbage was calculated according to an INRA method (Andrieu and Weiss 1981).

Seed reproduction of flora grasses

Five grasses among the floral species sampled were at risk of extinction in some experimental pastures, namely *Aegilops geniculata* L. (Gr-3), *Dasypyrum villosum* (L.) Borbas (Gr-2), *Stipa barbata* (Desf.) (Gr-19), *Lolium perenne* (L.) (Gr-13) and *Phalaris minor* (L.) (GR-57). These grasses were agronomically evaluated under favourable environments for seed production and yield components. In all experimental pastures, at physiological maturity of seed, plants of the five floral species were harvested manually. In the laboratory, biomass was threshed and seed dehulled and then used in a seed germination test and field agronomic experiment. The germination test was performed in a germination room kept at a constant temperature of 21°C for 25 days in the dark. For each floral species, 10 replicates of 100 seeds were placed in 10 × 1.5-cm diameter Petri dishes. The seeds were placed on two layers of Whatman No. 1 filter paper and watered with 5 ml of distilled water (Spreafico 1978; ISTAT 2010). Water was added daily as needed for maintaining the filter paper wet. The number of germinated seeds (seeds were considered to have been emerged when the radicle emerged at least 2 mm) were counted and removed daily but recorded for the 5^{th}, 10^{th}, 15^{th}, 20^{th} and 25^{th} days. Germination rate index (GRI) was determined according to the formula of Pieper (1952):

$$GRI = \Sigma(nxd)/N$$

where n = number of seed that germinated per day; d = number of days needed for germination; N = total number of germinated seeds.

Seeds of floral species Gr-2, Gr-3, Gr-13, Gr-9 and Gr-57 were sown at a density of 450 geminated seed m^{-2}, equivalent to 3.2, 1.7, 0.8, 1.4 and 1.0 g seed m^{-2}, respectively. Seeds were sown in a 7.5 m^2 plot in rows (5 m long and 0.18 m apart) by drill seeders in the three years (2000 to 2003) at the experimental farm "Menichella" of the Forage Crop Institute at Foggia (Italy). Seedbeds were prepared in September using a mouldboard plough that inverted soil to a depth of 35 cm. The ploughed soil was smoothed with a field cultivator and tine harrow a week later. The soil was fertilized during seedbed preparation with 27 kg ha^{-1} of N and 72 kg ha^{-1} of P_2O_5 (as biphosphate of ammonia) and in the 2^{nd} week of February, when there was a cover crop, with 60 kg ha^{-1} of N (as ammonia sulphate). Seeding was performed after the autumn rain when the moisture of soil guarantees good seed germination (normally at beginning of October) in a split plot, randomized block design with four replications. On a plot basis, during crop evaluation, the following traits on flowering data were determined from the 1^{st} January: stem density, biomass and seed yield; from two 50-cm sets of rows seed yield components were determined: stem m^{-2}, seed $spike^{-1}$, seed weight $spike^{-1}$, and 1000-seed weight. To avoid seed being lost by shattering, at seed physiological maturity the crop was swathed and, when dry, it was threshed.

Statistical analysis

An analysis of variance (ANOVA) of floral species and herbage production characteristics was established according to a split plot in a time and space design where the year of evaluation was arranged as the whole unit and experimental pastures as the subunits. The model considers year and replication as random and location as fixed effects (Steel and Torrie 1980). The effect of year, experimental pasture and the one-way interaction (E×Y) were tested with the pooled error. The comparisons among means over the experimental pastures of botanical family were performed according to the LSD statistical test at $P \geq 0.05$. To identify the most productive DM floral species, data of all periods of evaluation were analysed according to Scott and Knott (1974) cluster analysis techniques as described by Gates and Bilbro (1978) for each botanical family. Experimental pasture data of floral species for each botanical family and total DM were grouped according to a λ distribution. The λ statistic, as defined by Edwards and Cavalli-Sforza (1965), when applied to univariate means of data, is a random variable with a Student's distribution. Calculations of λ partitions divided the DM floral species mean of each botanical family and the total DM of experimental pastures into groups in which inter- and intra-group means showed a maximum and minimum sum square variability, respectively. The analysis identified and created, on the basis of the likelihood ratio test (Gates and Bilbro 1978), different cluster groups. The means within cluster groups had a minimum mean square interaction and were not statistically significant while the mean of each cluster group was significantly different at $P \geq 0.05$ from those of other groups.

The seed germination test was statistically analysed according to ANOVA. In the model the source of variation was the daily interval of seed germination replicated ten times. Comparison among daily germination interval was made by Duncan's multiple range test (DMRT) at $P \geq 0.05$.

ANOVA of the agronomical field experiment was established according to a split plot in a time and space model where the year of evaluation was considered as the main plot, forage and seed harvests as subplots and floral species were replicated four times within each subplot. In the model, replication and year were considered to be random and harvest and flora species had fixed effects (Steel and Torrie 1980). The effect of year and flora species and their one-way interaction (Y×E) was tested with the pooled error term. The mean of seed yield and seed yield components of floral species over the years was performed according to DMRT (Steel and Torrie 1980).

The relationships between means over the years of evaluation of floral species number belonging to a particular botanical family and with defined meteorological and topsoil characteristics was determined by correlation analysis testing the *r* value with a Student's table at n = 18 degrees of freedom.

RESULTS

All experimental pastures had alkaline soil pH, high organic matter, total nitrogen and exchangeable K_2O content, lower available P_2O_5 and de Martonne aridity index not exceeding 36. The patterns of mean temperature, rain and aridity index that were observed for the experimental pastures equalled those of arid environments of the Mediterranean bioclimatic zones of the UNOSCO-FAO (1963). The trend of yearly rainfall in the area of experiment pastures fell to 74% of the total amount between October and May while in the other months the precipitation was considered to be erratic (**Table 1**).

The significantly lower r values between botanical families and soil than with weather parameters evidenced that the weather pattern rather than soil characteristics affected the make up of floral species in pastures (**Table 2**). Among meteorological parameters, rainfall affected the number of floral species present in all pastures. Those species belonging to the Graminaceae and Compositae families were affected by all meteorological characteristics while altitude affected the floral species of the Labiatae, Caryophyllaceae, Cruciferae, Plantaginaceae and Umbelliferae, and aridity index affected all members of the Rubiaceae and Umbelliferae. Among chemical soil content, nitrogen influenced the number of flora species in the Leguminosae, Labiatae and Umbelliferae, available P_2O_5 the Umbelliferae and K_2O the Plantaginaceae and Umbelliferae.

The mean square of the main source Y and E sources was statistically significant and affected the development of floral species of all the botanical families (**Table 3**), total DM, chemical components and the MFU of the herbage (**Table 4**). The high statistical significance of the one-way interaction (ExY) and the variability and mean square values among traits was evidence that the development of a botanical family, DM, qualitative characteristics and MFU of herbage (**Table 4**) were differently influenced by weather conditions that occurred throughout the year of evaluation.

The mean of number of floral species over all experimental pastures of the Graminaceae was 16, higher than the number of species in the Leguminosae, Compositae and miscellaneous group which had 5, 4 and 8 flora less species, respectively (**Fig. 2**). The number of floral species in the other botanical families was strongly reduced (3 each in the Labiatae and Umbelliferae and 2 in the remaining families).

The variability among botanical families in terms of

Table 2 Correlation coefficient among meteorological and topsoil biochemical traits and main botanical family.

Botanical family	Meteorological characteristics				Soil characteristics			
	Altitude [a]	T °C [b]	Rainfall [c]	Aridity index [d]	Organic matter [e]	Total nitrogen [f]	Available P [g]	Exchangeable K [h]
Graminaceae	0.44*	0.45*	0.46*	0.66**	ns	ns	ns	ns
Leguminosea	ns	ns	0.47*	ns	ns	0.46*	ns	ns
Compositae	0.51*	0.59**	0.45*	0.63**	ns	ns	ns	ns
Labiatae	0.65**	ns	0.47*	ns	ns	0.49*	ns	ns
Caryophylaceae	0.35*	ns	0.47*	ns	ns	ns	ns	ns
Cruciferae	0.34*	ns	0.47*	ns	ns	ns	ns	ns
Liliaceae	ns	ns	0.47*	ns	ns	ns	ns	ns
Rubiaceae	ns	ns	0.47*	0.34*	ns	ns	ns	0.44*
Plantaginaceae	0.44*	ns	0.47*	ns	ns	ns	0.44*	0.43*
Umbelliferae	0.44*	ns	0.47*	0.55*	0.45*	0.44*	ns	ns

r statistical significant values at * and ** at 0.05 and 0.01 probability level, respectively
ns = not statistically significant. (n = 18 degrees of freedom)
[a] m above see level
[b] ° C degree Celcius
[c] yearly mm of water
[d] n
[e] and [f] g/100 g
[g] and [h] mg/g

Table 3 Mean squares and significant values of year and experimental pastures effects on botanical family.

Source of variation	df	Graminaceae [a]	Leguminosea [b]	Compositae [c]	Labiatae [d]	Liliaceae [e]
Year (Y)	2	1632 **	4147 **	212 **	579 **	4905 **
Error	9	745	122	22	24	116
Experimental pastures (E)	19	22103 **	2861 **	1773 **	385 **	4408 **
Interaction YxE	38	4837 **	1145 **	652 **	254 **	1414 **
Error	171	862	197	250	41	184
	Caryophyllaceae [f]	Cruciferae [g]	Rubiaceae [h]	Plantaginaceae [i]	Umbelliferae [l]	
Year (Y)	86 **	37 **	50 **	54 **	65 **	
Error	19	6	3	7	9	
Experimental pastures (E)	59 *	305 **	58 **	69 **	66 **	
Interaction YxE	65 **	112 **	50 **	36 **	49 **	
Error	18	7	4	5	6	

* and **: significant at 0.05 and 0.01 probability levels, respectively
[a] to [l] %

Table 4 Mean squares and significant values of year and experimental pastures effects on DM and chemical nutritional characteristics of biomass.

Source of variation	df	DM [a]	CP [b]	CF [c]	NDF [d]	ADF [e]	ADL [f]	MFU [g]
Year (Y)	2	12121 **	83 **	296 **	1737 **	966 **	99 **	1110 **
Error	9	1396	12	22	16	4	2	13
Experiment (E)	19	26245 **	79 **	91 **	243 **	112 **	34 **	1121 **
Interaction YxE	38	14890 **	10 **	17 **	79 **	38 **	36**	18 **
Error	171	1488	2	3	7	3	2	4

* and **: significant at $P \geq 0.05$ and 0.01 probability levels, respectively
[a] g m^{-2}
[a] to [f] %
[g] kg dry matter

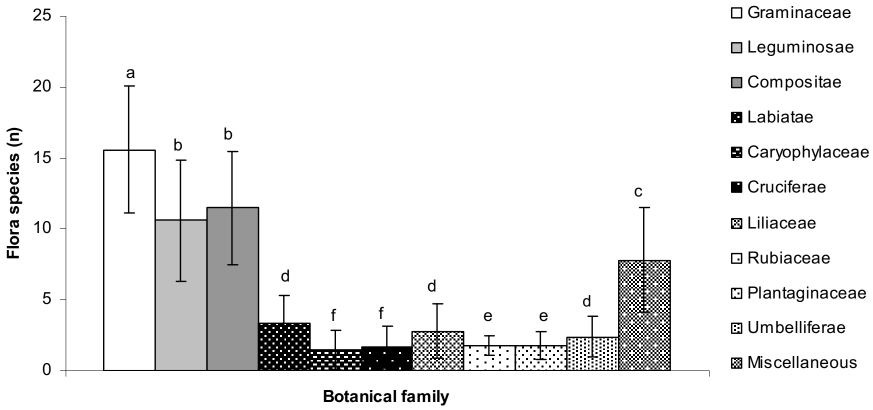


Fig. 2 Mean over experimental pastures of flora species number belong to the botanical family. Bars represent standard errors. Botanical family means followed by the same letter are not significantly different at $P \geq 0.05$.

total biomass of the sward was related to the number of floral species. The contribution of botanical families by the Graminaceae, Leguminosae, Compositae and miscellaneous group to the biomass in the sward was 27, 19, 20 and 13% of the total herbage production, respectively while the other families contributed a lower amount (**Fig. 3**). One direct consequence of plant morphology of the floral species was the contribution to total DM production, 48, 12, 12 and 8% by the Graminaceae, Leguminosae, Compositae and miscellaneous group, respectively (**Fig. 4**). The remaining 20% of DM was shared among the other botanical families (5% in Labiatae, 4% in Liliaceae, 3% in Umbelliferae, 2% in Cru-

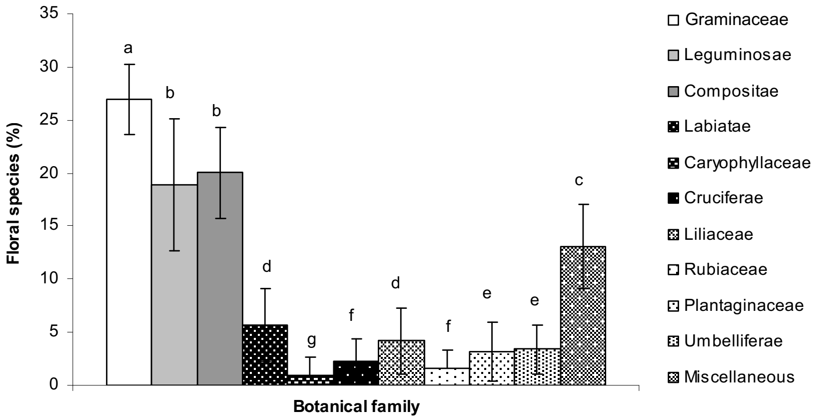


Fig. 3 Mean biomass contribution (in percentage) to total herbage yield over experimental pastures of botanical family. Botanical family means followed by the same letter are not significantly different at $P \geq 0.05$.

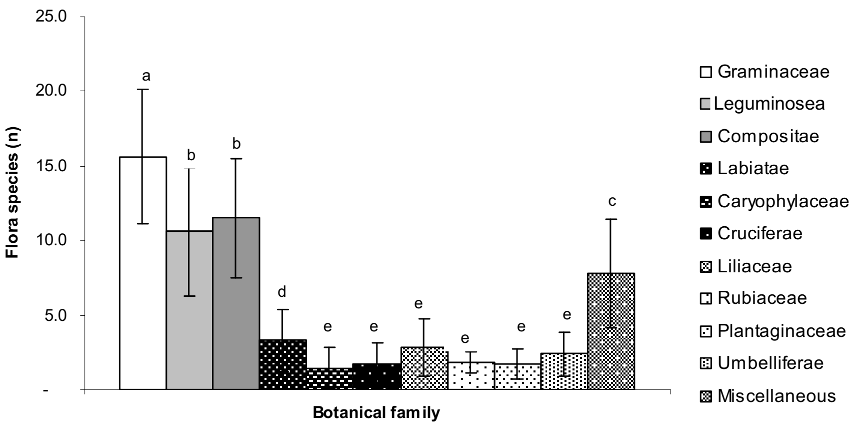
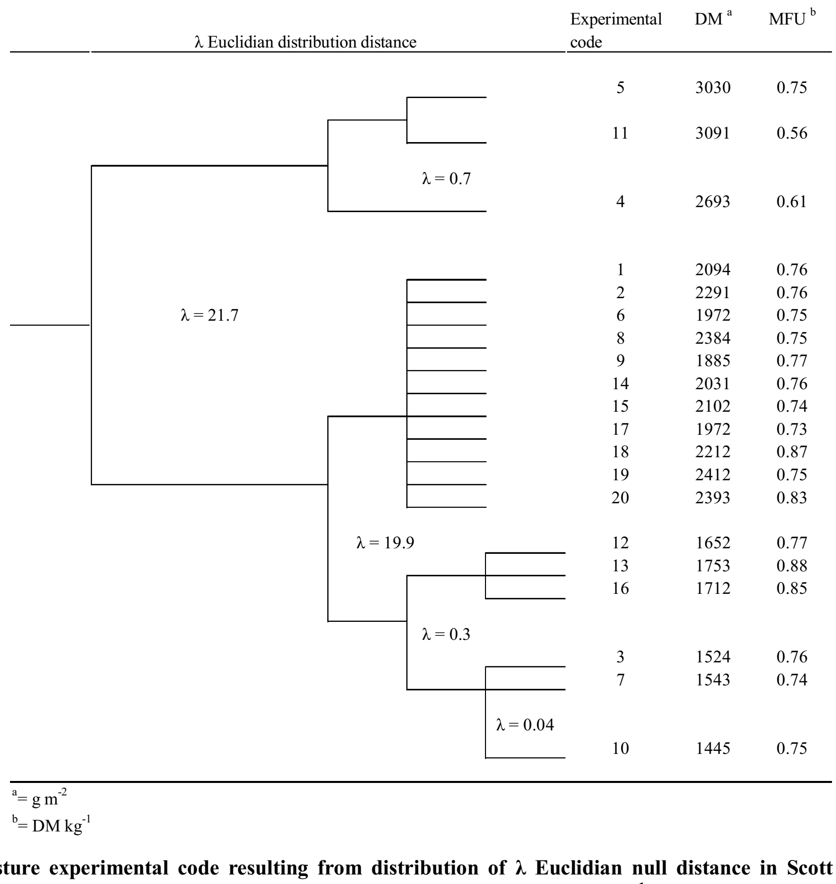


Fig. 4 Dry matter mean contribution (in percentage) to total production over experimental pasture of flora species belong to botanical families. Botanical family means followed by the same letter are not significantly different at $P \geq 0.05$.



[a]= g m^{-2}
[b]= DM kg^{-1}

Fig. 5 Dendrogram of pasture experimental code resulting from distribution of λ Euclidian null distance in Scott and Knott (1974) cluster analysis method for homogeneous grouping means of the univariate data of the DM and MFU ha^{-1} traits.

Table 5 Flora species with highest dry matter yield in the pasture of the experiments.

Pasturelands code	Graminaceae[a]	Leguminosae[b]	Compositae[c]	Labiatae[d]	Liliaceae[e]	Caryophyllaceae[f]	Cruciferae[g]	Rubiaceae[h]	Plantaginaceae[i]	Umbelliferae[l]	Miscellaneous[m]
Code 1	Gr-19	Le-8	Co-4	La-7	Li-3	Ca-2	Cr-1	Ru-2	Pl-3	Um-9	Bo-3
Code 2	Gr-15	Le-11	Co-19	La-3	Li-2	Ca-12	Cr-3	Ru-3	Pl-3	Um-2	Ra-1
Code 3	Gr-19	Le-56	Co-97	La-20	Li-5	Ca-13	Cr-5	Ru-4	Pl-1	Um-13	Ra-1
Code 4	Gr-3	Le-14	Co-97	La-3	Li-6	Ca-8	Cr-7	Ru-4	Pl-3	Um-10	Ra-1
Code 5	Gr-2	Le-4	Co-5	La-6	Li-9	Ca-2	Cr-5	Ru-5	Pl-2	Um-10	Sc-1
Code 6	Gr-3	Le-30	Co-5	La-3	Li-10	Ca-6	Cr-11	Ru-7	Pl-5	Um-10	Bo-3
Code 7	Gr-2	Le-4	Co-8	La-5	Li-6	Ca-7	Cr-9	Ru-3	Pl-4	Um-10	Eu-1
Code 8	Gr-21	Le-14	Co-4	La-6	Li-12	Ca-8	Cr-4	Ru-6	Pl-1	Um-15	Bo-2
Code 9	Gr-3	Le-14	Co-17	La-31	Li-6	Ca-9	Cr-7	Ru-2	Pl-4	Um-20	Sc-6
Code 10	Gr-1	Le-9	Co-5	La-15	Li-17	Ca-13	Cr-5	Ru-3	Pl-3	Um-21	Am-1
Code 11	Gr-2	Le-14	Co-5	La-13	Li-22	Ca-11	Cr-5	Ru-2	Pl-1	Um-15	Pa-1
Code 12	Gr-2	Le-64	Co-5	La-6	Li-6	Ca-1	Cr-21	Ru-3	Pl-2	Um-10	Bo-6
Code 13	Gr-2	Le-14	Co-97	La-6	Li-9	Ca-6	Cr-5	Ru-6	Pl-5	Um-11	Ma-4
Code 14	Gr-3	Le-11	Co-5	La-2	Li-8	Ca-8	Cr-5	Ru-2	Pl-3	Um-2	Po-3
Code 15	Gr-19	Le-15	Co-97	La-31	Li-6	Ca-13	Cr-10	Ru-4	Pl-1	Um-7	Sc-6
Code 16	Gr-3	Le-56	Co-6	La-12	Li-6	Ca-6	Cr-6	Ru-2	Pl-1	Um-21	Eu-2
Code 17	Gr-19	Le-17	Co-97	La-3	Li-6	Ca-1	Cr-3	Ru-3	Pl-2	Um-5	Bo-1
Code 18	Gr-19	Le-51	Co-46	La-5	Li-19	Ca-5	Cr-18	Ru-2	Pl-4	Um-8	Pr-1
Code 19	Gr-30	Le-8	Co-8	La-10	Li-6	Ca-11	Cr-16	Ru-2	Pl-4	Um-20	Pa-1
Code 20	Gr-2	Le-9	Co-60	La-18	Li-6	Ca-6	Cr-12	Ru-2	Pl-2	Um-5	Bo-7

[a] to [c] code of scientific name reported in **Appendix Table 1**
[d] to [l] code of scientific name reported in **Appendix Table 2**
[m] code of scientific name reported in **Appendix Table 3**

ciferae, Plantaginaceae and Rubiaceae and 1% in Caryophyllaceae) (**Fig. 4**).

The biodiversity of herbage over the environmental pastures amounted to 361 floral species 26% of which belonged to the Graminaceae, 17% to the Leguminosae, 19% to the Compositae, 5% to the Labiatae and Liliaceae, 4% to the Umbelliferae, 3% to the Cruciferae, Plantaginaceae and Rubiaceae, 2% to the Caryophyllaceae and 13% to the miscellaneous group (**Appendix Tables 1-2**). The floral species in other families was quite reduced, i.e., < 1% (**Appendix Table 3**).

The most productive floral species in terms of DM for each botanical family among experimental pastures was singled out in the first cluster group following Scott and Knott (1974) cluster analysis method (**Table 5**). The flora with code Li-6 was mostly diffused in 10 pastures while the group of species (Gr-2, Le-11, Co-5, Cr-5), (Gr-19, Gr-3, Ru-3, Pl-1, Pl-3, Um-10), (La-6, La-3, Pl-2, Pl-4, Ra-1) and (Co-97, Ca-13, Ru-4) were commonly shared in 6, 5, 4 and 3 experimental pastures. The means of total DM of the experimental pastures were clustered, after Scott and Knott (1974) analysis, into six statistically significantly different clusters characterized by decreasing values of λ between branching groups (**Fig. 5**). The means of DM yield of experimental pastures of the first group was 12, 29.5, 44.3, 49.9 and 52.8% higher than the DM yield of groups II to VI, respectively (**Fig. 5**). Moreover, the discrepancy observed between the mean DM and MFU pasture traits was ascribed to a difference in floral species composition and DM production which influenced the MFU of the sward (**Appendix Tables 1, 2, 3**).

The botanical variability of the flora among experimental pastures affected the quality components of herbage feeding values (**Fig. 6**). However, because the DM of floral species within the Graminaceae prevailed in the sward herbage, the fibre components (CF, NDF and ADF) were more represented than CP and ADL chemical values (**Fig. 6**). Correlations among the content of floral species in botanical families and MFU of the herbage showed that the Graminaceae were significantly correlated with CF and NDF (r = 0.53 and 0.67, respectively) and the Leguminosae with CP (r = 78) while the content of floral species of other dicotyledons and the miscellaneous group positively influence ADL (r = 0.49 and 0.56, respectively). All r values above and over 0.53 were statistically correlated at $P \geq 0.05$ and $P \geq 0.01$, respectively.

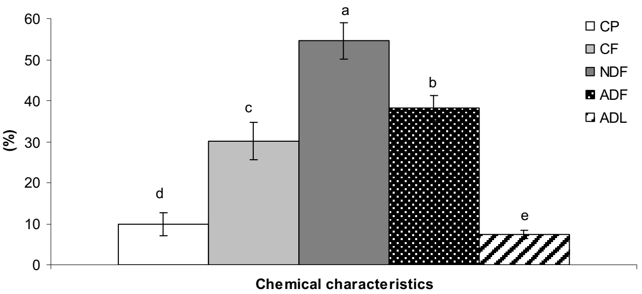


Fig. 6 Mean over experimental pastures of chemical qualitative characteristics of sward biomass. CP (crude protein), CF (crude fibre), NDF (neutral-detergent fibre), ADF (acid-detergent fibre), ADL (acid-detergent lignin).

The effect of grazing assessed on pasturelands with sheep belong to Sardinian landrace sheep at about 0.2, 1.0 and 4.0 LU ha^{-1} with flock composed by different number of animals (2, 6 and 24 sheep ha^{-1}) induced variation in DM production, MFU and variation in the floral composition of undisturbed herbage biomass (**Table 7**). The trend in the reduction of biomass production and DM traits was about similar in the grazing pasture with a stocking rate of 4.0 LU ha^{-1}: 33.6 and 44.7% in March, 16.7 and 47.8% in April and 55.8 and 72.1% in May with a 1.0 and 0.2 LU ha^{-1} stocking rate, respectively (**Table 7**). The low variation that existed among biomass and DM among stocking rates was due to a similar moisture content at harvest of biomass in the stocking rates. The reduction in MFU in the stocking rates (0.2 to 4.0 LU ha^{-1}) of March, April and May grazing (0.12, 0.11 and 0.25 MFU, respectively) was a consequence of the selection effect on flora made by animal grazing which reduces herbage production and the MFU value. The variation observed among stocking rates and time of pasture grazing was a consequence of the selection effect of animal grazing on floral species composition in the botanical family of each pasture's sward whose yielding potential and qualitative nutritive feeding value of herbage was reduced.

Table 6 Seed weight, seed germination test and germination rate index of the flora species evaluated for seed production.

Flora species	Flora code [a]	1000 seed weight [b, f]	Seed germination test [c]					Total seed germinated [d, f]	GRI [e, f]
			5 days[f]	10 days[f]	15 days[f]	20 days[f]	25 days[f]		
Aegilops geniculata	Gr-3	3.68 b	94 a	3 d	0	0	0[f]	97 a	23.5 a
Dasypyrum villosum	Gr-2	6.12 a	83 b	3 d	1 c	0	0	87 b	20.8 b
Lolium perenne	Gr-13	1.61 d	31 c	55 a	4 b	2 b	2 a	96 a	13.6 c
Phalaris minor	Gr-57	2.12 c	85 b	10 c	1 c	0	0	96 a	20.1 b
Stipa barbata	Gr-19	1.21 e	26 c	35 b	21 a	11 a	1 a	94 a	11.9 d

[a] code of scientific name reported in **Appendix Table 1**
[b] g
[c] %
[d] %
[e] Germination Rate Index
[f] in the trait, means of flora species with the same letter are not statistically differed at $P \geq 0.05$ according to Duncan's multiple range test

Table 7 Sheep number for stocking rate, month of plant height to initial grazing, biomass production, qualitative characteristic of dry matter (milk feeding unit, MFU) and botanical family flora composition of ungrazed biomass at each stocking rate land unit hectare (LU ha^{-1}).

LU ha^{-1} [a]	Sheep[b]	Beginning of grazing [c]	Biomass [d]	Dry matter [d]	MFU[e]	Graminaceae [f]	Leguminosae [f]	Compositae [f]	Miscellaneous [f]
		March				1° Grazing			
0.2	2		2156	476.5	0.68	82	2.5	6.0	9.5
1	6		1798	343.7	0.61	78	1.9	6.8	13.3
4	24		1193	294.7	0.56	69	1.6	7.3	22.1
LSD 0.05 [g]			44	8.9	0.3	3	0.9	1.9	3.5
		April				2° Grazing			
0.2	2		1875	746.2	0.66	79	4.2	8.7	8.1
1	6		1175	468.8	0.58	70	3.3	9.4	17.3
4	24		978	390.2	0.55	56	2.3	12.6	29.1
LSD 0.05 [g]			67	13.4	0.2	6	0.4	1.1	2.3
		May				3° Grazing			
0.2	2		847	750	0.64	65	5.1	10.5	9.4
1	6		534	216.6	0.49	56	4.8	12.7	26.5
4	24		236	94.4	0.39	34	2.8	20.9	42.3
LSD 0.05 [g]			52	10.4	0.3	05	0.1	2.4	10.8

[a] Stocking rate of sheep (LU ha^{-1} y^{-1}= 6 adult sheep)
[b] number of sheep ha^{-1}
[c] month of beginning to graze
[d] g m^{-2}
[e] kg dry matter^{-1}
[f] % of chemical compound on dry matter
[g] LSD, Least Significant Difference statistical test at $P \geq 0.05$

Table 8 Mean biomass and seed yield and seed yield component traits of flora species under field agronomic evaluation.

Flora species	Flora code [a]	Flowering data [b, i]	Stem height [c, i]	Seed yield		Seed yield components		
				Biomass [d, i]	Seed [e, i]	Stem weight [f, i]	Seed weight [g, i]	Seeds spike [h, i]
Aegilops geniculata	Gr-3	96 b [i]	50 e [i]	1056 c [i]	79.7 b [i]	0.34 d [i]	0.08 b [i]	2.3 d [i]
Dasypyrum villosum	Gr-2	98 b	130 a	2115 a	93.7 a	1.28 a	0.11 a	9.5 b
Lolium perenne	Gr-13	115 a	68 d	1725 b	39.3 d	0.63 c	0.09 b	17.2 a
Phalaris minor	Gr-57	99 c	103 b	2099 a	36.3 c	1.03 b	0.06 c	7.1 c
Stipa barbata	Gr-19	109 b	72 c	224 d	29.2 e	0.18 e	0.02 d	2.4 d

[a] code of scientific name reported in **Appendix Table 1**
[b] days from 1st January
[c] cm
[d] g m^{-2}
[e] g m^{-2}
[f] g stem^{-1}
[g] g 1000 seeds
[h] number of seeds spike^{-1}
[i] means with the different letter are statistically significant at $P = 0.05$ probability level, according to Duncan's multiple range test

The DM (%)content in the Graminaceae and Leguminosae family was strongly stressed in 4.0 LU ha^{-1} or > 0.2 LU ha^{-1} stocking rates, respectively by 15.9 and 36.0% in March, by 29.1 and 45.2% in April and by 47.7 and 45.1% in May (**Table 7**). In contrast, an opposite trend of variation was observed in the DM% of floral species belongs to the Compositae and miscellaneous group across stocking rates. Particularly in May grazing, the percentage of DM of 4.0 LU ha^{-1} stocking rate was 49.8 and 39.2% in the Compositae and 77.7 and 37.4% in the miscellaneous group, higher than 0.2 and 1 LU ha^{-1} stocking rates, respectively. The floral composition of the 4.0 LU ha^{-1} stocking rate in the March, April and May grazing were characterized by 6 floral genera (*Centaurea* spp., *Cirsium* spp., *Asphodelus* spp., *Cichorium* spp., *Euphorbia* spp., and *Galium* spp.) characterized by an advanced phonological stage of plant development, namely rough, woody and thorny morphological organs, which had low desirability and which were not preferred by any animal during the grazing period.

Characteristics of the seeds of five floral species differed: seed weight, seed germination and GRI (**Table 6**). Seed germination was related to seed weight (r = 0.80, significant at $P \geq 0.01$). After 5 days, the floral species Gr-3, Gr-57 and Gr-2 had a seed germination > 83% while the percentage for Gr-13 and Gr-19 was reduced by 31 and 26%, respectively. After 10 days, the percentage of seed that germinated was > 85% in Gr-3, Gr-57, Gr-2, Gr-13 and > 66% in Gr-19. The longer period of seed germination and the lower GRI observed in Gr-13 and G-19 may be ascribed, as is commonly found in clovers (Iannucci *et al.* 2000) and in caper (*Capper ovata* L.) (Basbag *et al*. 2009), to a higher adaptability to temperature than other species.

The floral species differed in terms of flowering time, stem height and biomass, and seed production (**Table 8**). The range of variation in traits (lower and higher value) was, respectively Gr-3 and Gr-13 for flowering time, Gr-3 and Gr-2 for stem height, Gr-2 and Gr-19 for biomass and Gr-19 and Gr-2 for seed production (**Table 8**). Seed production among floral species (Gr-2 14.8, 58.1, 61.3 and 68.7% higher than Gr-3, Gr-13, Gr-57 and Gr-19, respectively) was not related to biomass yield (r = 0.33 ns with n = 3 df). Mean seed yield components of several traits (1000-seed weight, stem and seed weight and spike fertility) affected morphological diversity in the floral species differently according to DMRT (**Tables 4, 8**).

DISCUSSION

In agreement with studies conducted on Mediterranean floral biodiversity by Talamucci *et al*. (1996), Bernués *et al*. (2004), Abdelguerfi and Abdelguerfi-Laouar (2004), Casasús *et al*. (2004) and Martiniello and Berardo (2007), the floral composition of the experimental pastures were similar to those found in the UNESCO-FAO's meso-Mediterranean zones (**Appendix Tables 1, 2, 3**). The highly statistical significant one-way (YxE) interactions of several traits (i.e., botanical families, DM, chemical characteristics and components of biomass) was a consequences of the influence of weather conditions on floral species development rather than topsoil characteristics (**Table 2**) (Martiniello 1998; Heywood and Skoula 1999; Plantureux *et al*. 2005: Tastad *et al*. 2010). Furthermore, the higher mean square values of the one-way interaction (ExY) in four botanical families (Graminaceae, Compositae, Leguminosae, Liliaceae) and DM than in other botanical families evidenced that weather and soil characteristics influenced plant development and qualitative chemical composition of the herbage to different degrees (**Table 3**).

According to Heywood and Skoula (1999), Perevolotsky and Seligman (1998), Plantureux *et al*. (2005), Mounir *et al*. (2009) and Tastad *et al*. (2010), the evolution of biodiversity existing among experimental pastures may be a consequences of weather rather than topsoil characteristics and anthropic factors which indirectly interfere with the development of herbage in a sward (**Table 7**).

In agreement with Clergué *et al*. (2005), Plantureux *et al*. (2005), Mounir *et al*. (2009) and Tastad *et al*. (2010), the higher biodiversity observed among the Graminaceae, Leguminosae and Compositae, whose number of floral species ranged from 9 to 23, 6 to 22 and 6 to 18, respectively, may be ascribed to favourable adaptability of their flora to the edaphic, anthropogenic and environmental factors (**Fig. 2**). Thus, as a consequence of higher number of floral species in these botanical families, their contribution in the biomass of experimental pastures in swards ranged from 22 to 34% in the Graminaceae, 8 to 29% in the Leguminosae and 15 to 29% in the Compositae (**Fig. 3**). However, the diversity in DM among botanical families was mainly the consequence of plant morphological development rather than to the number of floral species associated with them (**Fig. 4**). According to Martiniello and Teixeira da Silva (2011), the DM diversity among botanical families is linked to the physiological and chemical characteristics of morphological organs (leaf, stem and root) with environmental conditions during plant development that influence the relocation of stored compounds in plant organs. The biochemical processes of DM production in botanical species were linked to environmental conditions and to phenological stages of stem and leaf development. Environmental stress that occurs during the period of vegetative growth interferes with the development of morphological organs in plants and with physiological activity of DM production among flora, reducing the relocation of proteins and water-soluble carbohydrates in all plant organs. Therefore, the higher contribution to total DM production by the Graminaceae than by other families was a consequence of more efficient plant morphologic structures endowed by physiological mechanisms of adaptability to weather conditions and plant development of floral species therein (**Fig. 4**).

According to Tastad *et al*. (2010), total DM production among experimental pastures was related to the viability of environmental resources able to restore the ecological processes of a balanced and sustainable pasture ecosystem. The bioclimatic influence on plant development of herbs in the sward among experimental pastures affected the contribution by DM of botanical families to total DM production. Thus, among pastures, the contribution of botanical families ranged from 41 to 63% in the Graminaceae, 6 to 21% in the Leguminosae and 6 to 20% in the Compositae (**Appendix Table 1**) while in the other families (**Appendix Table 2**) and miscellaneous group the range was strongly reduced (1 to 9% in dicotyledons and 4 to 12% in the miscellaneous group) (**Appendix Table 3**).

The Scott and Knott (1974) cluster analysis of total DM evidenced 6 different ecosystems in which a favourable combination of weather and soil characteristics interfered with plant development of floral species (**Fig. 5**). The mean of pastures' DM production of each ecosystem (cluster group) differed statistically from the others while the means of pasturelands in it included were not statistically significant; consequently, they had similar DM yield potential. According to Heywood and Skoula (1999), Abdelguerfi and Laouar (2000), Abdelkefi and Marrakchi (2000), Plantureux *et al*. (2005) and Tastad *et al*. (2010), the agro-ecosystem advantages affected the development of the floral species in the sward of the experimental pasture differently, determining the lack of an association between MFU and DM in the same ecosystem of the experimental pastures.

The lower MFU value of experimental pastures with codes 11 and 4, in comparison to those with higher values (codes 13, 16, 18 and 20), were due to the content and development of floral species belonging to different botanical families (**Appendix Tables 1, 2, 3**).

In all experimental pastures, the percentage of herbage DM of Graminaceae prevailed over those of others botanical families (26, 19, 20, 6, 1, 2, 4, 2, 3, and 13 for Graminaceae, Leguminosae, Compositae, Labiatae, Caryophyllaceae, Cruciferae, Liliaceae, Rubiaceae, Plantaginaceae and Umbelliferae and Miscellaneous group, respectively) (**Fig. 3**). Thus, the chemical contents of fibre (CF, NDF and ADF) assessed by the INRA laboratory methodology of Andrieu and Weiss (1981), maintain that flora species of the Graminaceae are the chemical components mostly represented in the MFU of the herbage (**Fig. 6**).

The contribution of floral species to DM production in each botanical family varied across the experimental pastures. Thus, because the Graminaceae floral species were the most represented and productive in terms of DM in all experimental pastures evidenced a wider adaptability of this botanical family to ecosystem biodiversity than those less represented (**Fig. 3**). In agreement with Clergué *et al*. (2005) and Plantureux *et al*. (2005), the flora species present in more than experimental pastures such as Li-6 (11 pastures), Gr-2, Le-11, Cr-5, and Pl-1 (6 pastures) and Gr-3, Gr-19, Ru-3, Pl-1, Pl-5 and Um-10 in (5 pastures) may be considered as indicators to evaluate the functions of flora to edaphic adaptability and environmental factors and achieve favourable biodiversity restoration in the pastureland area (**Table 5**).

The high seed germination and GRI parameters of floral species (Gr-2, Gr-3, Gr-13 and Gr-57) and the low values of GRI in Gr-19 may evidence different means by which grasses establish seedlings under favourable weather (rain and temperature) conditions in Mediterranean climatic zones (**Table 6**). The higher GRI and seed germination percentage after 10 days in the species Gr-2, Gr-3, Gr-13 and Gr-57 than in Gr-19 allowed those species under favourable water and temperature condition to establish seedlings, after 5-6 days after seeding, in environmental bioclimatic zones of the Mediterranean climate, conferring higher adaptation to germinate in the first rain of autumn months. By contrast, the longer period of seed germination of Gr-19 may confer to the species wider adaptability to cope with a wide range of temperature and drought conditions of the same environments. Thus, in agreement with the observations made by Basbag *et al*. (2009) in caper, the seed of floral species studied may be endowed with different mechanisms of adaptability during seedling establishment. The floral species with codes Gr-2, Gr-3, Gr-13 and Gr-57 suddenly exploit favourable early weather conditions more than Gr-19.

The field evaluation discovered bioagronomic differences in morphological, seed yield and seed yield components among the five flora species of Graminaceae botanical family, providing agronomic information necessary for seed production allowing for them to be reseeded (**Table 8**). The seed production of wild species, by using the agronomic practices adopted for cultivation of domesticated forage crops (Martiniello 1999, 2006), may be useful and utilised for producing seed of floral species under the risk of extinction providing a possibility for a large amount of seed of autochthonously adapted germplasm to reseed in degraded pastures (Abdelkefi and Marrakchi 2000; Bounejmate *et al*. 2004). In agreement with the suggestions of Bernués *et al*. (2004), Clergué *et al*. (2005), Platureux *et al*. (2005), Mounir *et al*. (2009) and Tastad *et al*. (2010), the use of agronomic practices for seed production of floral species under the risk of extinction under favourable environments in order to provide seed stock to reseed may represent a scientific means to reduce the risk of genetic erosion of floral species present in the pasture swards of the Mediterranean environments.

CONCLUSIONS

Floral surveys represent an essential scientific means to protect, add value and maintain the ecological condition of natural habitats and provide the appropriately collected germplasm for further genomic and molecular phylogenetic studies. The lack of useful floral species biodiversity in Mediterranean environments of the European Union represent an ecological risk of pasturelands whose recovery requires a political strategy by the States of the Mediterranean Basin to prevent or reduce the threat of desertification of these environments. This study achieved various successes: monitoring the floral biodiversity, feeding values of herbage and agronomic possibility to obtain seed from extinguishing germplasm to be reseeded in experimental pastures. These results are useful to obtain knowledge on floral composition and on agronomic techniques for seed production of flora at a risk of degradation to be reseeded in degraded pastures in such a way as to favour the natural equilibrium needed to recover the ecological role of the floral species in Mediterranean environments.

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Appendix Table 1 Floral species codes belonging to the Gramineae, Leguminosae and Compositae botanical families and their percentage of total dry mass (DM) production.

Experimental pastures code[a]	Gramineae Species code [b]	Gramineae DM % [c]	Leguminosae Species code [b]	Leguminosae DM % [c]	Compositae Species code [b]	Compositae DM % [c]
1	Gr-1, Gr-15, Gr-19, Gr-21, Gr-24, Gr-27, Gr-29, Gr-31, Gr-33, Gr-34, Gr-38	53	Le-4, Le-8, Le-11, Le-13, Le-23, Le-25, Le-32, Le-33, Le-35, Le-42, Le-51	21	Co-3, Co-5, Co-16, Co-17, Co-19, Co-20, Co-21, Co-24	8
2	Gr-1, Gr-2, Gr-6, Gr-13, Gr-15, Gr-19, Gr-22, Gr-27, Gr-30, Gr-33, Gr-34, Gr-35, Gr-38, Gr-54	55	Le-4, Le-6, Le-7, Le-8, Le-10, Le-11, Le-16, Le-21, Le-24, Le-32, Le-33, Le-36, Le-37, Le-38	18	Co-3, Co-10, Co-12, Co-15, Co-17, Co-19, Co-23, Co-24, Co-46	5
3	Gr-1, Gr-3, Gr-6, Gr-19, Gr-27, Gr-28, Gr-33, Gr-34, Gr-37, Gr-48	46	Le-3, Le-4, Le-8, Le-9, Le-10, Le-12, Le-13, Le-17, Le-56	21	Co-3, Co-16, Co-19, Co-23, Co-24, Co-46	13
4	Gr-1, Gr-2, Gr-3, Gr-4, Gr-6, Gr-7, Gr-15, GR-19, Gr-22, Gr-29, Gr-37, Gr-38, Gr-40	41	Le-5, Le-7, Le-8, Le-9, Le-14, Le-16, Le-21, Le-33, Le-51	18	Co-6, Co-16, Co-19, Co-20, Co-23, Co-25, Co-27, Co-28	19
5	Gr-1, Gr-2, Gr-3, Gr-6, Gr-7, Gr-13, Gr-15, GR-19, Gr-24, Gr-26, Gr-27, Gr-30, Gr-33, Gr-37, Gr-38, Gr-39, Gr-40	44	Le-1, Le-4, Le-7, Le-8, Le-10, Le-16, Le-17, Le-37, Le-39, Le-51, Le-70	16	Co-3, Co-5, Co-10, Co-19, Co-24, Co-29, Co-32, Co-79, Co-82	6
6	Gr-1, Gr-2, Gr-3, Gr-4, Gr-5, Gr-6, Gr-9, Gr-15, Gr-22, Gr-24, Gr-27, Gr-28, Gr-30, Gr-31, Gr-33, Gr-40, Gr-41, Gr-44, Gr-48	48	Le-4, Le-6, Le-7, Le-8, Le-9, Le-10, Le-16, Le-24, Le-25, Le-26, Le-28, Le-29, Le-32, Le-35, Le-40, Le-41, Le-42, Le-43, Le-44, Le-51, Le-56, Le-67	12	Co-5, Co-6, Co-10, Co-15, Co-19, Co-20, Co-30, Co-31, Co-32, Co-33, Co-34, Co-35, Co-36, Co-83, Co-102, Co-103	10
7	Gr-1, Gr-2, Gr-3, Gr-4, Gr-6, Gr-7, Gr-13, Gr-15, Gr-19, Gr-22, Gr-30, Gr-33, Gr-38, Gr-40, Gr-41, Gr-42, Gr-43, Gr-53, Gr-55, Gr-56, Gr-57	46	Le-4, Le-6, Le-8, Le-9, Le-16, Le-21, Le-44, Le-45, Le-46, Le-51	8	Co-4, Co-5, Co-8, Co-16, Co-19, Co-24, Co-30, Co-31, Co-37, Co-38, Co-39, Co-40, Co-41, Co-42, Co-74	10
8	Gr-1, Gr-2, Gr-3, Gr-4, Gr-6, Gr-9, Gr-14, Gr-19, Gr-21, Gr-22, Gr-27, Gr-30, Gr-32, Gr-33, Gr-38, Gr-39, Gr-41, Gr-43, Gr-46, Gr-64, Gr-65	42	Le-3, Le-14, Le-16, Le-31, Le-44, Le-46, Le-51, Le-56	12	Co-3, Co-4, Co-5, Co-8, Co-9, Co-17, Co-19, Co-23, Co-24, Co-29, Co-31, Co-38, Co-43, Co-45, Co-46, Co-47, Co-50, Co-53, Co-104	10
9	Gr-1, Gr-2, Gr-3, Gr-4, Gr-6, Gr-7, Gr-19, Gr-22, Gr-24, Gr-26, Gr-27, Gr-30, Gr-31, Gr-33, Gr-34, Gr-39, Gr-40, Gr-44, Gr-45, Gr-48, Gr-49, Gr-55	43	Le-3, Le-4, Le-5, Le-7, Le-8, Le-9, Le-11, Le-14, Le-70	11	Co-2, Co-4, Co-5, Co-7, Co-9, Co-15, Co-19, Co-20, Co-24, Co-42, Co-48, Co-49, Co-50, Co-51, Co-52, Co-79	8
10	Gr-1, Gr-2, Gr-3, Gr-4, Gr-6, Gr-13, Gr-19, Gr-21, Gr-22, Gr-24, Gr-27, Gr-30, Gr-33, Gr-36, Gr-38, Gr-39, Gr-40, Gr-41, Gr-44, Gr-47, Gr-54, Gr-58, Gr-59	50	Le-4, Le-6, Le-7, Le-9, Le-12, Le-14, Le-16, Le-22, Le-24, Le-26, Le-31, Le-47, Le-51	12	Co-5, Co-6, Co-18, Co-19, Co-24, Co-34, Co-38, Co-40, Co-56, Co-66, Co-86, Co-87	8
11	Gr-2, Gr-5, Gr-6, Gr-13, Gr-22, Gr-27, Gr-30, Gr-33, Gr-38, Gr-43, Gr-Gr-44, Gr-57	68	Le-1, Le-3, Le-4, Le-14, Le-16, Le-21, Le-44, Le-70	6	Co-4, Co-5, Co-17, Co-41, Co-53, Co-58, Co-59, Co-60, Co-84, Co-88, Co-89, Co-90	13
12	Gr-1, Gr-2, Gr-3, Gr-4, Gr-5, Gr-6, Gr-7, Gr-15, Gr-19, Gr-21, Gr-27, Gr-30, Gr-33, Gr-38, Gr-39, Gr-40, Gr-48, Gr-49, Gr-55, Gr-60, Gr-61, Gr-67	42	Le-4, Le-7, Le-8, Le-9, Le-11, Le-16, Le-21, Le-24, Le-41, Le-44, Le-48, Le-49, Le-51, Le-56, Le-58, Le-59, Le-69, Le-71	11	Co-3, Co-15, Co-16, Co-17, Co-18, Co-19, Co-23, Co-24, Co-38, Co-54, Co-55, Co-59, Co-60, Co-61, Co-62, Co-63, Co-64, Co-68	13
13	Gr-1, Gr-2, Gr-3, Gr-5, Gr-6, Gr-19, Gr-25, Gr-27, Gr-38, Gr-43, Gr-50, Gr-55	60	Le-1, Le-5, Le-11, Le-14, Le-16, Le-51, Le-60, Le-61	6	Co-10, Co-16, Co-20, Co-23, Co-24, Co-34, Co-41, Co-44, Co-65, Co-66, Co-90, Co-92	15
14	Gr-1, Gr-2, Gr-3, Gr-4, Gr-6, Gr-12, Gr-15, Gr-19, Gr-20, Gr-22, Gr-24, Gr-26, Gr-30, Gr-34, Gr-38, Gr-43, Gr-66	40	Le-4, Le-7, Le-8, Le-11, Le-14, Le-15, Le-16, Le-17, Le-19, Le-21, Le-22, Le-23, Le-24, Le-25, Le-27, Le-56, Le-68	13	Co-4, Co-5, Co-16, Co-19, Co-32, Co-38, Co-39, Co-54, Co-93, Co-94	22
15	Gr-1, Gr-2, Gr-3, Gr-4, Gr-7, Gr-15, Gr-19, Gr-24, Gr-30, Gr-33, Gr-38, Gr-39, Gr-40, Gr-41, Gr-51, Gr-61, Gr-62	49	Le-4, Le-7, Le-8, Le-15, Le-16, Le-17, Le-51, Le-52, Le-62, Le-70	8	Co-4, Co-8, Co-11, Co-16, Co-23, Co-24, Co-36, Co-55, Co-60, Co-68, Co-69 Co-70, Co-93, Co-95	14
16	Gr-1, Gr-2, Gr-3, Gr-7, Gr-15, Gr-19, Gr-20, Gr-23, Gr-24, Gr-30, Gr-38, Gr-40, Gr-41, Gr-52, Gr-61	46	Le-7, Le-8, Le-9, Le-12, Le-15, Le-16, Le-29, Le-51, Le-53, Le-56, Le-63	9	Co-5, Co-6, Co-7, Co-8, Co-12, Co-16, Co-19, Co-23, Co-35, Co-36, Co-43, Co-69, Co-71, Co-94, Co-95	15
17	Gr-1, Gr-2, Gr-3, Gr-4, Gr-7, Gr-15, Gr-19, Gr-24, Gr-27, Gr-28, Gr-29, Gr-30, Gr-33, Gr-41, Gr-53, Gr-69	47	Le-4, Le-8, Le-9, Le-10, Le-27, Le-64, Le-65, Le-66	8	Co-2, Co-8, Co-15, Co-16, Co-19, Co-36, Co-41, Co-60, Co-68, Co-73, Co-74 Co-75, Co-96, Co-97, Co-98	7
18	Gr-1, Gr-2, Gr-3, Gr-6, Gr-7, Gr-19, Gr-27, Gr-30, Gr-38, Gr-39, Gr-40, Gr-41, Gr-44, Gr-48, Gr-53	57	Le-4, Le-7, Le-8, Le-9, Le-16, Le-64, Le-65, Le-66	8	Co-12, Co-15, Co-24, Co-41, Co-69, Co-96, Co-97, Co-98	12
19	Gr-1, Gr-2, Gr-3, Gr-6, Gr-13, Gr-27, Gr-29,Gr-30, Gr-38, Gr-39, Gr-40, Gr-44, Gr-47, Gr-55	41	Le-4, Le-7, Le-8, Le-9, Le-16, Le-24, Le-41, Le-48, Le-51, Le-54	11	Co-4, Co-10, Co-19, Co-34, Co-41, Co-60, Co-69, Co-76, Co-77, Co-78, Co-79	19
20	Gr-1, Gr-2, Gr-3, Gr-13, Gr-29, Gr-30, Gr-38, Gr-39, Gr-43, Gr-47	46	Le-1, Le-3, Le-8, Le-16, Le-32, Le-38, Le-44, Le-51, Le-56	12	Co-19, Co-34, Co-38, Co-46, Co-60, Co-80	13

[a] Code of pasture identification see **Table 1**

[b] Botanical name of flora species see **Appendix Table 4**

[c] Botanical family DM weight/total DM × 100 in a 1 m^2 of pasture sward surface

Appendix Table 2 Flora species codes belonged Labiateae, Liliaceae, Cariophyllaceae, Crucifereae Rubiaceae, Plantaginaceae and Umbelliferae botanical families and their percentage of total DM production.

Esperimental	Labiatae		Liliaceae		Cariophyllaceae		Crucifereae		Rubiaceae		Plantaginaceae		Umbelliferae	
pasture code [a]	Species code [b]	DM [c]	Species code [b]	DM [c]	Species code [b]	DM [c]	Species code [b]	DM [c]	Species code [b]	DM [c]	Species code [b]	DM [c]	Species code [b]	DM [c]
1	La-6, La-7, La-16	3	Li-1, Li-5, Li-8, Li-14	2	Ca-1	1	Cr-5	2	Ru-2	3	Pl-2, Pl-3	2	Um-1, Um-6	1
2			Li-9, Li-15	5	Ca-5	1	Cr-4	2	Ru-2	1	Pl-1	1	Um-8	1
3	La-1, La-2, La-6	4	Li-10, Li-11, Li-16	6	Ca-2	1	Cr-11	1	Ru-2	1	Pl-1, Pl-2, Pl-3, Pl-5	4	Um-2, Um-3, Um-4	1
4	La-3, La-4, La-24	3	Li-2, Li-12	1	Ca-7	1	Cr-8	1	Ru-2	1	Pl-1, Pl-2, Pl-3, Pl-5	4	Um-3, Um-9	1
5	La-3, La-6, La-9, La-10, La-11, La-12	7	Li-1, Li-2, Li-13	1	Ca-10	1	Cr-7, Cr-8, Cr-16	4	Ru-2	2	Pl-1, Pl-2, Pl-3	4	Um-1, Um-8, Um-3, Um-6	3
6	La-3, La-5	5	Li-2, Li-16	2	Ca-1, Ca-2, Ca-5, Ca-6	8	Cr-3, Cr-9, Cr-16	3	Ru-2	2	Pl-1, Pl-2, Pl-3	2	Um-8, Um-10	3
7	La-3, La-6, La-11, La-12, La-13, La-14, La-18	7	Li-4, Li-5, Li-6, Li-12, Li-13, Li-14	5	Ca-5, Ca-7, Ca-10, Ca-11	6	Cr-5, Cr-10, Cr-11, Cr-12, Cr-16, Cr-17	7	Ru-2, Ru-5	2	Pl-3	2	Um-2, Um-9, Um-6, Um-11, Um-18, Um-19	4
8	La-6, La-11, La-15, La-18	6	Li-14	2	Ca-8, Ca-12	3	Cr-4, Cr-5, Cr-12	6	Ru-5	2	Pl-1, Pl-3	4	Um-1, Um-6, Um-15	3
9	La-5, La-8, La-11, La-14, La-15, La-31	9	Li-4, Li-6, Li-14	4	Ca-9, Ca-13	3	Cr-11	1	Ru-2, Ru-35	3	Pl-3	2	Um-5, Um-8, Um-9, Um-20, Um-21	8
10	La-23, La-30	4	Li-1, Li-2, Li-5	3	Ca-5	1	Cr-5	3	Ru-2, Ru-3, Ru-6	5	Pl-3	3	Um-18, Um-19	4
11	La-5, La13, La-14, La-18, La-19	5	Li-1, Li-15	1	Ca-7	1	Cr-12	1	Ru-2	1	Pl-1	1	Um-1, Um-3, Um-4	6
12	La-17, La-18, La-24	4	Li-12, Li-13, Li-14, Li-15, Li-20, Li-21, Li-22	7	Ca-11	1	Cr-4	1	Ru-6, Ru-14, Ru-15	3	Pl-1	1	Um-1, Um-7, Um-8, Um-12, Um-13, Um-15, Um-16	9
13	La-6, La-22, La-25, La-26	5	Li-1, Li-2, Li-16	2	Ca-2	1	Cr-12	1	Ru-4	1	Pl-1	1	Um-14, Um-19	2
14	La-2, La-3	5	Li-1, Li-12	1	Ca-2	1	Cr-5, Cr-12	3	Ru-2, Ru-4	2	Pl-1	1	Um-1, Um-9, Um-15	7
15	La-18, La-20, La-21, La-22, La-31	5	Li-3, Li-4, Li-6, Li-13	3	Ca-5	1	Cr-1	1	Ru-2, Ru-3	2	Pl-1, Pl-3, Pl-4	3	Um-1, Um-8, Um-9, Um-16, Um-19	4
16	La-3	1	Li-6, Li-14, Li-17, Li-18	6	Ca-11	1	Cr-6	1	Ru-2, Ru-3	3	Pl-2	2	Um-2, Um-8, Um-17, Um-20	5
17	La-3, La-5, La-6, La-22, La-27, La-28	8	Li-3, Li-4, Li-6, Li-7, Li-12, Li-19	9	Ca-1	2	Cr-12	3	Ru-2, Ru-3	3	Pl-3	2	Um-4, Um-8, Um-9, Um-19	4
18	La-11, La-23, La-27, La-28	6	Li-2, Li-4, Li-12, Li-19	4	Ca-7	1	Cr-1, Cr-12	2	Ru-2, Ru-4	2	Pl-3	1	Um-8, Um-9, Um-16, Um-19	2
19	La-10, La-29	5	Li-4, Li-13, Li-14	6	Ca-5	1	Cr-12	1	Ru-2, Ru-7	2	Pl-1, Pl-2	2	Um-2, Um-3, Um-8, Um-9	4
20	La-12	4	Li-1, Li-2, Li-6, Li-12	7	Ca-2	1	Cr-6	1	Ru-4, Ru-14	4	Pl-1	1	Um-2, Um-8, Um-13, Um-15	6

[a] Code of pasture identification see **Table 1**
[b] Botanical name of flora species seed Appendix flora species code table
[c] Botanical family dry matter weight divided total dry matter by 100 in a 1 m^2 of pasture sward surface

Appendix Table 3 Flora species codes (with lower 1% of total DM) belong to miscellaneous group and their percentage in the total DM yield of the sward.

Experimental pasture code [a]	Miscellaneous group	
	Code of floral species [b]	**DM [c] %**
1	Bo-2, Co-10, Gr-17, Ra-5, Sc-1, Sc-7, Ve-1	6
2	Cn-3, Gr-18, Pa-1, Pa-3, Ra-1, Ra-3	7
3	Cy-3, Cy-4, Ir-1, Oc-2, Ra-1, Um-16	6
4	Cp-1, Di-1, Le-5, Le-70, Ra-1, Ra-2	10
5	Cn-3, Cy-3, Cy-4, Di-1, Fi-1, Fi-2, Pa-1, Pa-2, Ra-2, Sc-1, Sc-6	11
6	Bo-3, Cn-1, Cn-2, Cp-1, Eu-1, Eu-2, La-30, Pa-1, Pr-1	5
7	Co-13, Cp-1, Cy-2, Eu-1, Eu-2, Ir-2, Oc-1, Pa-1, Pr-1, Ra-6	4
8	Bo-3, Bo-4, Eu-2, Ge-1, Gr-31, Ma-1, Ma-3	10
9	Bo-1, Bo-2, Bo-3, Bo-5, Co-10, Cn-2, Eu-2, Or-1, Pa-1, Sc-6	9
10	Am-1, Cy-4, Cy-5, Oc-3, Pa-1, Pa-4, Po-2, Pr-1, Sc-1, Sc-2, Sc-7, Ve-1	12
11	Co-57, Pa-1, Pa-2, Pa-3, Um-19	6
12	Cp-1, Bo-6, Bo-7, Cn-3, Cn-4, Di-1, Gr-16, Gr-29, Oc-1, Pa-2, Pr-1, Ra-1, Ra-2, Sc-6, Ve-1	11
13	Ch-2, Ir-3, Ma-2, Ma-4, Pr-3, Ra-1	9
14	Bo-3, Co-1, Co-14, Co-54, Cp-2, Le-70, Oc-4, Pa-1, Po-3, Pr-3	7
15	Co-72, Cy-4, Eu-2, Oc-3, Or-1, Pa-1, Pr-1, Pr-2, Pr-3, Sc-4, Sc-6, Sc-8	12
16	Eu-1, Eu-2, Oc-1, Pa-1, Pr-1, Pr-2, Sc-4, Sc-5, Sc-6, Sc-8	10
17	Bo-1, Co-26, Cp-1, Pr-1, Pr-2, Sc-8, Sc-9	7
18	Cp-1, Pa-1, Pr-1, Pr-2, Ra-4, Ra-6, Sc-8, Sc-9	6
19	Bo-8, Co-67, Gr-29, Le-5, Pa-1, Um-6	8
20	Bo-7, Co-53, Gr-8, Gr-10, Gr-11, La-24, Po-4	8

[a] Code of pasture identification see **Table 1**
[b] Botanical name of flora species seed Appendix flora species code table
[c] Botanical family dry matter weight divided total dry matter by 100 in a 1 m^2 of pasture sward surface

Appendix 4 Floral species code. Codes of botanical family (two letters) and flora species code (number with one or two digits hyphened to family code) of the classified sward herbs.

Botanical species

***Amaranthaceae* (Am-nn)**
Am-01 *Amaranthus retroflexus* L.

***Boraginaceae* (Bo-nn)**
Bo-01 *Symphytum officinale* L.
Bo-02 *Borago laxiflora* W.
Bo-03 *Echium vulgare* L.
Bo-04 *Heliotropium europeum* L.
Bo-05 *Cynoglossum nebrodense* Guss.
Bo-06 *Myosotis arvensis* Hill
Bo-07 *Echium arenarium* Guss.
Bo-08 *Echium italicum* L.

***Campanulaceae* (Cp-nn)**
Cp-01 *Campanula garganica* Ten.
Cp-02 *Campanula cochlearifolia* Lam.

***Cariophyllaceae* (Ca-nn)**
Ca-01 *Cerastium manticum* L.
Ca-02 *Silene saxifraga* L.
Ca-03 *Spergula pentandra* L.
Ca-04 *Dracocephalum Ruyschiana* L.
Ca-05 *Silene quadrifida* L.
Ca-06 *Gypsophila elegans* M.B.
Ca-07 *Stellaria palustris* L.
Ca-08 *Lychnis coeli-rosa* Desr.
Ca-09 *Alsine tenuifolia* Crantz.
Ca-10 *Silene cretica* L.
Ca-11 *Lychnis coronaria* Desr.
Ca-12 *Cerastium cerastoides* Britt.
Ca-13 *Silene gallica* L.
Ca-14 *Silene rubella* L.

***Chenopodiaceae* (Ch-nn)**
Ch-01 *Chenopodium rubrum* L
Ch-02 *Chenopodium botrys* L.

***Compositae* (Co-nn)**
Co-01 *Taraxacum apenninum* DC.
Co-02 *Senecio delphinifolius* Vahl
Co-03 *Senecio vulgaris* L.
Co-04 *Carlina corymbosa* L.
Co-05 *Cirsium spinosissimum* Scop.
Co-06 *Cirsium syriacum* Gaertn.
Co-07 *Cirsium polyanthemum* Spr.
Co-08 *Cardopatium corymbosum* Pers.
Co-09 *Cichorium intybus* L.
Co-10 *Leucanthemum vulgare* Lam.
Co-11 *Taraxacum officinale* Web.
Co-12 *Leontodon cichoraceus* Sang.
Co-13 *Carduus crispus* L.
Co-14 *Centaurea jacea* L.
Co-15 *Tragopogon porrifolius* L.
Co-16 *Centaurea subtilis* Bert.
Co-17 *Chrysanthemum coronarium* L.
Co-18 *Chrysanthemum cinerariaefolium* Vis.
Co-19 *Sonchus oleraceus* L.
Co-20 *Carduncellus pinnatus* DC.
Co-21 *Carduus acanthoides* L.
Co-22 *Cirsium spimosissimum* Scop.
Co-23 *Cirsium afrum* DC.
Co-24 *Carlina macrocephala* Moris
Co-25 *Tussilago farfara* L.
Co-26 *Centaurea scabioasa* L.
Co-27 *Centaurea umbrosa* Lac.
Co-28 *Centaurea rupestris* L.
Co-29 *Sonchus asper* L.
Co-30 *Carduus chrysacanthus* Ten.
Co-31 *Chrysanthemum segetum* L.
Co-32 *Achillea tomentosa* L.
Co-33 *Sinapis procumbens* Prior.
Co-34 *Tragopogon dubius* Scop.
Co-35 *Centaurea nigra* Fiore
Co-36 *Cirsium microcephalum* Moris
Co-37 *Carduus tenuifolius* Curt.
Co-38 *Matricaria chamomilla* L.
Co-39 *Carlina acaulis* L.
Co-40 *Carduus affinis* Guss.
Co-41 *Carduus cephalanthus* Viv.
Co-42 *Geropogon glaber* L.
Co-43 *Calendula hortensis* Fiori
Co-44 *Cirsium stellatum* Spr.
Co-45 *Cirsium arvense* Scop.
Co-46 *Onopordon illyricum* L.
Co-47 *Santomilla chameacyparissus* L.
Co-48 *Centaurea alba* L.
Co-49 *Carlina vulgaris* L.
Co-50 *Centaurea solstitialis* L.
Co-51 *Cirsium italicum* DC.
Co-52 *Centaurea melitensis* L.
Co-53 *Carthamus tinctorius* L.
Co-54 *Carlina lanata* L
Co-55 *Bidens cernua* L.
Co-56 *Coronilla juncea* L.
Co-57 *Carduus eriophorus lanceolatus* L.
Co-58 *Carthamus caeruleus* L.
Co-59 *Carthamus lanatus* L.
Co-60 *Carduus pycnocephalus* L.
Co-61 *Sonchus maritimus* L.
Co-62 *Cirsium eriophorum* Scop.
Co-63 *Anthemis mixta* L.
Co-64 *Crupina vulgaris* Cass.
Co-65 *Scorzanera calcitrapifolia* Vahl
Co-66 *Cirsyum echinatum* DC.
Co-67 *Carduus arvensis*
Co-68 *Centaurea filiformis* Viv.
Co-69 *Rhagadiolus stellatus* Gaertn.
Co-70 *Leontodon circhoraceus* Sang.
Co-71 *Erigeron crispus* Pourr.
Co-72 *Carduus argyroa* Biv.
Co-73 *Tolpis virgata* Bert.
Co-74 *Centaurea cyanus* L.
Co-75 *Aster sedifolius* L.
Co-76 *Centaurea paniculata* L.
Co-77 *Echinops sphaerocephalus* L
Co-78 *Carlina sicula* Ten.
Co-79 *Erigeron canadiensis* L.
Co-80 *Cirsium lanceolatum* Hill.

***Geraniaceae* (Ge-nn)**
Ge-01 *Erodium gruinum* (L.) L'Her. ex Aiton

***Gramineae* (Gr-nn)**
Gr-01 *Dactylis glomerata* L.
Gr-02 *Dasypirum villosum* (L.) Borbas.
Gr-03 *Aegilops ovata* L.
Gr-04 *Bromus fasciculatus* Presl.
Gr-05 *Agropyrum repens* P.B.
Gr-06 *Lolium rigidum* Gaud.
Gr-07 *Nardus stricta* L.
Gr-08 *Elymus europaeus* L.
Gr-09 *Agrostis pallida* DC.
Gr-10 *Agrostis alba* L.
Gr-11 *Imperata cylindrica* P.B.
Gr-12 *Lolium multiflorum* Lam.
Gr-13 *Lolium perenne* L.
Gr-14 *Sclerochloa divaricata* L.K.
Gr-15 *Brachypodium distachyum* P.B.
Gr-16 *Lygeum spartum* L.
Gr-17 *Stipa tortilis* Desf.
Gr-18 *Phleum echinatum* Host
Gr-19 *Stipa barbata* Desf.
Gr-20 *Stipa bromoides* Doerfl.
Gr-21 *Festuca rubra* L.
Gr-22 *Festuca caerulescens* Desf.
Gr-23 *Psilurus incurvatus* Schinz et Thell.
Gr-24 *Trisetum flavescens* P.B.
Gr-25 *Secale cereale* L.
Gr-26 *Phleum subulatum* Asch. et Gr.
Gr-27 *Bromus sterilis* L.
Gr-28 *Eleusine indica* Gaertn.
Gr-29 *Poa bulbosa* L.
Gr-30 *Avena fatua* L.
Gr-31 *Briza minor* L.
Gr-32 *Alopecurus pratense* L.
Gr-33 *Poa annua* L.
Gr-34 *Arrhenatherum elatius* M. et K.
Gr-35 *Avena bromoides* Gouan
Gr-36 *Bromus erectus* Huds.
Gr-37 *Anthoxanthum ovatum* Lag.
Gr-38 *Bromus hordeaceous* L.
Gr-39 *Pheum pratense* L.
Gr-40 *Lagurus ovatus* L.
Gr-41 *Stipa capillata* L.
Gr-42 *Glyceria fluitans* R. Br.
Gr-43 *Hordeum murinum* L.
Gr-44 *Briza maxima* L.
Gr-45 *Phalaris brachystachys* Link
Gr-46 *Sclerochloa rigida* (L.) Link
Gr-47 *Poa pratensis* L.
Gr-48 *Anthoxanthum aristatum* Boiss.
Gr-49 *Briza media* L.
Gr-50 *Setaria viridis* P.B.
Gr-51 *Cyperus levigatus* L.
Gr-52 *Phalaris paradoxa* L.
Gr-53 *Polypogon monspeliens* Desf.
Gr-54 *Trisetum villosum* (Bentol.) Schultes
Gr-55 *Bromus intermedius* Guss.
Gr-56 *Lepturus incurvatus* Schinz et Th.
Gr-57 *Phalaris minor* Retz.
Gr-58 *Sclerochloa hemipoa* Guss.
Gr-59 *Festuca arundinacea* Screb.
Gr-60 *Bromus villosus* Forsk.
Gr-61 *Briza minima* L.
Gr-62 *Vulpia geniculata* LK.
Gr-64 *Setaria glauca* P.B.
Gr-65 *Eragrostis Barrelieri* Dav.
Gr-66 *Festuca elatior* L.
Gr-67 *Vulpia incrassata* Parl.

***Iridaceae* (Ir-nn)**
Ir-01 *Sysirinchium bellum* L.
Ir-02 *Gladiolus segetum* Ker-Gawl.
Ir-03 *Iris florentino* L.

***Labiatae* (La-nn)**
La-01 *Galeopsis tetrahit* L.
La-02 *Lavandula stoechas* L.
La-03 *Lamium flexuosum* Ten.
La-04 *Thymus spinulosus* Ten.
La-05 *Thymus capitatus* H. et LK.
La-06 *Marrubium alysson* L.
La-07 *Dracocephalum ruyschiana* L.
La-08 *Acanthus longifolius* Host
La-09 *Stachys salviaefolia* Ten.
La-10 *Stachys densiflora* Benth.
La-11 *Stachys annua* L.
La-12 *Lamium garganicum* L.
La-13 *Lamium purpureum* L.
La-14 *Leonurus Marrubiastrum* L.
La-15 *Marrubium vulgare* L.
La-16 *Stachys Reinert* Heldr.
La-17 *Satureja cuneifolia* Ten.

Appendix 4 (Cont.)

Botanical species

La-18 *Stachys hirta* L.
La-19 *Stachys silvatica* L.
La-20 *Phomis viscosa* Poir.
La-21 *Lamium amplexicaule* L.
La-22 *Stachys arenaria* Vahl
La-23 *Stachys officinalis* Trevis.
La-24 *Satureja montana* L.
La-25 *Rosmarinus officinalis* L.
La-26 *Satureja fruticosa* Bég.
La-27 *Thymus vulgaris* L.
La-28 *Lavandula dentata* L.
La-29 *Salvia verticillate* L.
La-30 *Scutellaria altissima* L.
La-31 *Origanum vulgare* L.

***Leguminosae* (Le-nn)**
Le-01 *Trifolium repens* L.
Le-02 *Onobrichis caput-galli* (L.) Lam.
Le-03 *Astragalus echinatus* Murr.
Le-04 *Trifolium speciosum* W.
Le-05 *Ononis biflora* Desf.
Le-06 *Trifolium leucanthum* M.B.
Le-07 *Trifolium maritimum* Huds.
Le-08 *Trifolium incarnatum* L.
Le-09 *Trifolium suffocatum* L.
Le-10 *Trifolium subterraneum* L.
Le-11 *Trifolium resupinatum* L.
Le-12 *Hippocrepis multisiliquosa* L.
Le-13 *Hippocrepis comosa* L.
Le-14 *Medicago orbicularis* All.
Le-15 *Medicago truncatula* Gaertn.
Le-16 *Medicago disciformis* DC.
Le-17 *Lotus corniculatus* L.
Le-21 *Vicia sativa* L.
Le-22 *Melilotus sulcata* Desf.
Le-23 *Medicago italica* Steud.
Le-24 *Medicago ciliaris* Krock
Le-25 *Trifolium squarrosum* L.
Le-26 *Trifolium arvense* L.
Le-27 *Ononis spinosa* L.
Le-28 *Trifolium montanum* L.
Le-29 *Astragalus hamosus* L.
Le-31 *Trifolium stellatum* L.
Le-36 *Trifolium pratense* L.
Le-37 *Vicia lathyroides* L.
Le-38 *Lathyrus aphaca* L.
Le-39 *Medicago hispida* Gaertn.
Le-40 *Trifolium runens* L.
Le-41 *Astragalus uncinatus* Bert
Le-42 *Trifolium spumosum* L.
Le-43 *Coronilla juncea* L.
Le-44 *Medicago rugosa* Desr.
Le-45 *Medicago lupulina* L.
Le-46 *Medicago precox* DC.
Le-47 *Coronilla varia* L.
Le-48 *Vicia silvatica* L.
Le-49 *Vicia altissima* Desf.
Le-51 *Medicago arabica* Huds.
Le-52 *Anthyllis vulneraria* L.
Le-53 *Onobrychis aequidentata* D'Urv.
Le-54 *Medicago Tenoreana* Ser.
Le-56 *Onobrychis viciaefolia* Scop.
Le-58 *Lathyrus latifolius* L.
Le-59 *Trigonella gladiata* Stev.
Le-60 *Vicia pannonica* Crantz
Le-61 *Lathyrus annuus* L.
Le-62 *Astragalus depressus* L.
Le-63 *Lathyrus cicera* L.
Le-64 *Ononis pusilla* L.
Le-65 *Onobrychis caput-galli* Lam.
Le-66 *Genista silvestris* Scop.
Le-67 *Anthyllis maura* Beck
Le-68 *Trifolium alpinum* L.
Le-69 *Lathyrus angulatus* L
Le-70 *Hippocrepis ciliata* Willd.
Le-71 *Lathyrus hirsutus* L.

***Liliaceae* (Li-nn)**
Li-01 *Scilla italica* L.
Li-02 *Urginea fugax* (Moris) Steinh.
Li-03 *Allium rotundum* L.
Li-04 *Asparagus acutifolius* L.
Li-05 *Asparagus tenuifolius* Lam
Li-06 *Asphodelus ramosus* L.
Li-07 *Asparagus officinalis* L.
Li-08 *Colchicum autunnale* L.
Li-09 *Muscari commutatum* Guss.
Li-10 *Tulipa clusiana* Vent.
Li-11 *Fritillaria tenella* M. B.
Li-12 *Asparagus aphyllus* L.
Li-13 *Asphodeline lutea* Rchb.
Li-14 *Asphodelus albus* L.
Li-15 *Muscari maritimum* Desf.
Li-16 *Muscari muscarini* Medic.
Li-17 *Allium ampeloprasum* L.
Li-18 *Ornithogalum exscapum* Ten.
Li-19 *Allium cupani* Raf.
Li-20 *Dipcadi serotinum* Medic.
Li-21 *Allium oleraceum* L.
Li-22 *Ornithogalum arabicum* L.

***Malvaceae* (Ma-nn)**
Ma-01 *Malva silvestris* L.
Ma-02 *Hibiscus trionum* L.
Ma-03 *Malva rotundifolia* L.
Ma-04 *Malva moschata* L.

***Orchidaceae* (Oc-nn)**
Oc-01 *Orchis longibracteata* Biv.
Oc-02 *Ophrys arachnites* Reichard
Oc-03 *Orchis purpurea* Huds.
Oc-04 *Serapius vomeracea* L.

***Orobanchaceae* (Or-nn)**
Or-01 *Orobanche barbata* Poir.

***Papaveraceae* (Pa-nn)**
Pa-01 *Fumaria officinalis* L.
Pa-02 *Papaver rhoeas* L.
Pa-03 *Fumaria capreolata* L.
Pa-04 *Corydalis cava* Sch. et Krt.

***Plantaginaceae* (Pl-nn)**
Pl-01 *Plantago lanceolata* L.
Pl-02 *Plantago maritima* L.
Pl-03 *Plantago montana* Lam.
Pl-04 *Plantago amplexicaulis* Cav.
Pl-05 *Plantago serraia* L.

***Polygonaceae* (Po-nn)**
Po-01 *Polygonum napalense* Meisn.
Po-02 *Polygonum minus* Huds.
Po-03 *Rumex acetosella* L.
Po-04 *Rumex obtusifolius* L.

***Primulaceae* (Pr-nn)**
Pr-01 *Anagallis arvensis* L.
Pr-02 *Asterolium linum-stellatum* Duby
Pr-03 *Anagallis tenella* Murr.

***Ranunculaceae* (Ra-nn)**
Ra-01 *Ranunculus acer* L.
Ra-02 *Adonis vernalis* L.
Ra-03 *Ranunculus arvensis* L.
Ra-04 *Nigella damascena* L.
Ra-05 *Ranunculus auricomus* L.
Ra-06 *Nigella arvensis* L.

***Rubiaceae* (Ru-nn)**
Ru-01 *Asperula garganica* Huter
Ru-02 *Galium aparine* L
Ru-03 *Galium verum* L.
Ru-04 *Galium tricorne* Stok.
Ru-05 *Galium verticillatum* Danth.
Ru-06 *Sherardia arvensis* L.
Ru-07 *Galium austriacum* Jacq

***Scrophulariaceae* (Sc-nn)**
Sc-01 *Verbascum angustifolium* Ten.
Sc-02 *Digitalis ambigua* Murr.
Sc-03 *Melampirum arvense* L.
Sc-04 *Linaria purpurea* Mill.
Sc-05 *Linaria capraria* Mor. et D.
Sc-06 *Verbascum longifolium* Ten.
Sc-07 *Scrophularia lucida* L.
Sc-08 *Veronica chamaedrys* L.

***Umbelliferae* (Um-nn)**
Um-01 *Daucus carota* L.
Um-02 *Daucus muricatus* L.
Um-03 *Prangos carinata* Griserb.
Um-04 *Magydaris pastinacea* (Lam.) Paol.
Um-05 *Ferula silvatica* Bess.
Um-06 *Foeniculum vulgare* Mill.
Um-07 *Ammi visnaga* Lam.
Um-08 *Ferula ferulago* L.
Um-09 *Tordylium officinale* L.
Um-10 *Thapsia garganica* L.
Um-11 *Krubera peregrina* Hoffm.
Um-12 *Tordylium apulum* L.
Um-13 *Scandix brachycarpa* Guss.
Um-14 *Apium inundatum* (L.) Rchb.
Um-15 *Scandix pecten-veneris* L.
Um-16 *Bunium majus* Gouan
Um-17 *Peucedanum oreoselinum* Moench
Um-18 *Torilis nodosa* Gaertn.
Um-19 *Apium nodifloru* Lag.
Um-20 *Tordylium apulum* L.
Um-21 *Bupleurum stellatum* L.

***Verbanaceae* (Ve-nn)**
Ve-01 *Verbena officinalis* L.