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The classification of some plants subjected to disturbance factors (grazing and cutting) based on ecological strategies in Turkey

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Abstract
The effect of disturbance factors such as grazing and cutting were investigated in some plants in central Black Sea Region of Turkey using Grime's CSR strategies and Ellenberg's indicator values (EIVs). Grime's CSR strategies were also determined by Pierce et al.'s (Funct Ecol 27:1002–1010, 2013) scheme because there were some inconsistencies between Grime's and Pierce et al.'s schemes. Secondary strategies in the study area found to be dominant and the dominance of secondary strategies are consistent with "intermediate disturbance hypothesis". All the EIVs were found to be significantly different in grazed vs non-ungrazed and cutted vs uncutted areas. PCA diagram showed that ungrazed and cutted areas are associated with EIVR, while grazed and uncutted plots are associated with EIVL, EIVM, EIVN and EIVT.

Keywords Autecological plant traits · Central Black Sea Region · CSR strategies · Intermediate disturbance hypothesis · Principal component analysis (PCA) · Secondary strategies

1 Introduction

Grime's CSR (competitive (C), stress-tolerant (S), and ruderal (R) theory has been used for a long time in autecological studies because the proportion of species which exhibit different strategies is likely to change within vegetation in response to changing land use (Hodgson 1991). Grazing and cutting are the two main disturbance factors which derived from natural and antropogenical events may cause complexity and instability in species interactions (Fakhireh et al. 2012; Hüseyinova et al. 2013; Xu et al. 2016). Disturbance intensity and time are of particular importance because these factors creating diverse opportunities for establishment, growth and reproduction of a particular species (Pierce et al. 2007; Duru et al. 2010; Frenette-Dussault et al. 2012).

Ellenberg indicator values (EIVs) are used as an empirical tool to express the ecological response of plants to the environmental factors. EIVs are also widely used for the determination of plant functional traits and the evaluation of disturbance factors (Dzwonko 2001; Zelený and Schaffers 2011; Sürmen et al. 2014; Marceno and Guarino 2015; Del Vecchio et al. 2015). The main criteria used in Ellenberg's system are *L* (light), *T* (temperature), *M* (soil moisture), *R* (soil reaction), *N* (soil nitrogen concentration) and they are ordered from 1 to 9 (1–12 for moisture) scale (Pignatti et al. 2001; Testi et al. 2004; Crosti et al. 2010). This study is aimed to classify some plant species which are subjected to disturbance factors (grazing and cutting) in central Black Sea Region of Turkey using Grime's CSR classification scheme to find a better explanation of Grime's and Ellenberg's strategies and the underlying mechanisms. Pierce et al. (2013) made some revisions on the original Grime's system because Grime's classification scheme has some deficiencies. For

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example, flowering period and flowering time may change over years and they may probably be changed depending on the phenological development of a particular species. Therefore, plants species in grazed vs ungrazed and cutted vs uncutted areas were also classified according to Pierce et al.'s (2013) scheme. Ellenberg's indicator values (EIVs) describe the response of a species to edaphic and climatical parameters and ecological requirements of species across their distribution area (Coban 2016). Therefore, plant species were also classified using Ellenberg's indicator values (EIVs) to discuss the effects of disturbance factors.

2 Materials and methods

The study area is located in Yeşilırmak basin (Amasya city) in the central region of Turkey (40°39′03.35″N and 35°56′45.23″E) (Fig. 1). The mean annual temperature and the mean annual precipitation are 13.9 °C and 397.5 mm, respectively. The maximum mean temperature is 31.7 °C (August), while the lowest mean temperature is − 0.6 °C (January). The study area is located in a semi-arid and transitional-type climatic belt and it is a transitional area between oceanic and continental climates. Mediterranean climate can also be seen locally; therefore, the vegetation is a mix of Euxine, Irano-Turanian and Mediterranean species. The study area is dominated by chestnut-colored, a soil which is formed by calcification process. Goat, sheep and cow grazing is widespread in the study area. The number of goats, sheep and cows is 1870, 860 and 800, respectively. Irregular cutting is performed in the study area for lumbering (Turkish Republic of Ministry of Agriculture, Forestry and Rural Affairs 1991).

In the grazed areas, unpalatable and thorny species such as *Acantholimon acerosum* var. *acerosum*, *Achillea setacea*, *Carduus pycnocephalus* subsp. *albidus*, *Globularia trichosantha* are dominant, while the ungrazed areas are characterized by *Avena eriantha*, *Capsella bursa-pastoris*, *Hordeum vulgare*, *Taraxacum officinale*, and *Urtica dioica*. The cutted areas are characterized by *Cerasus mahaleb* (L.) Miller var. *mahaleb* (L.) Miller, *Cistus creticus* L., *Colutea arborescens* L., *Cruciata taurica* (Pallas ex Willd.) Ehrend, *Jasminum fruticans* L., *Pistacia terebinthus* L. subsp. *palaestina* (Boiss.) Engler, *Polygala pruinosa* Boiss. subsp. *pruinosa* Boiss., *Vicia narbonensis* L., while uncutted areas are dominated by *Arbutus andrachne* L., *Globularia trichosantha* Fisch., *Quercus petraea* (Mattuschka) Liebl., *Quercus hartwissiana* Steven, *Amelanchier rotundifolia* (Lam.) Dum.-Courset, *Phillyrea*

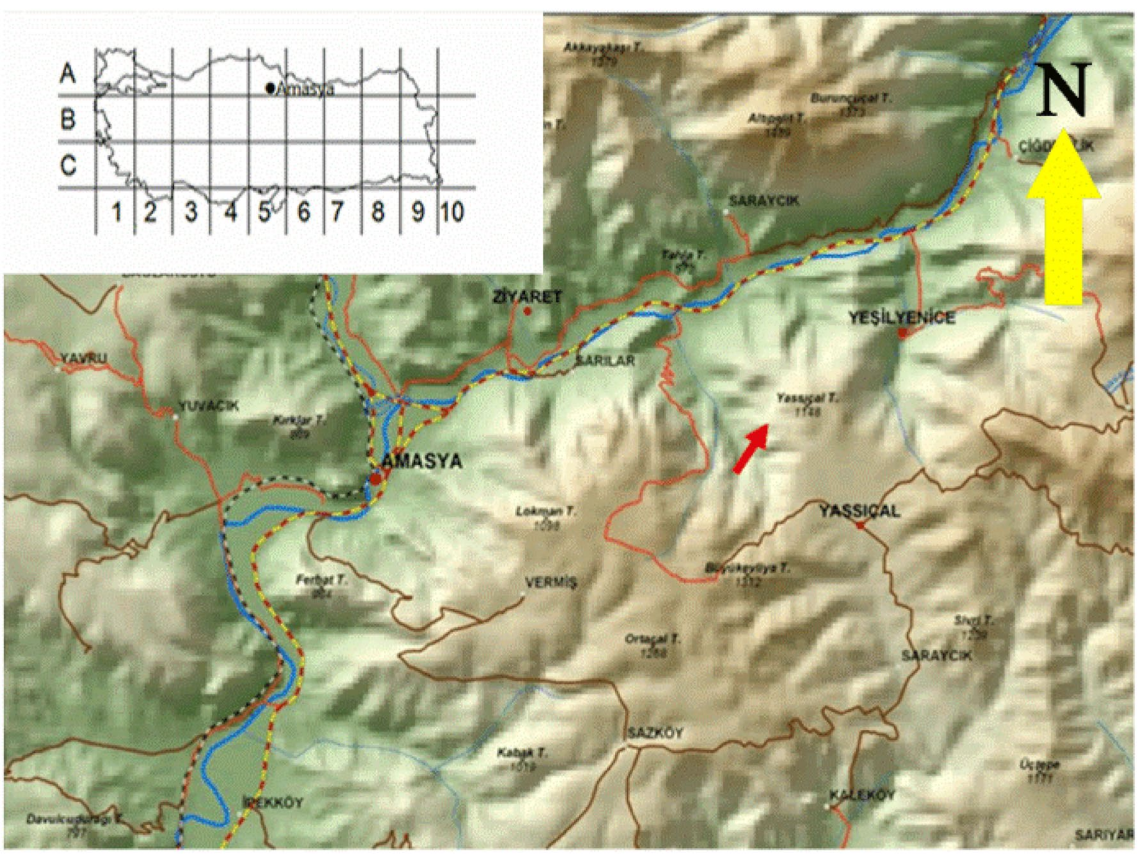

Fig. 1 Map of the study area (it was arranged using a 1/25.000 scale map)

latifolia L., *Juniperus oxycedrus* L. subsp. *oxycedrus*, *Euphorbia szovitsii* Fisch.&Mey., *E. rigida* Bieb., *Marrubium vulgare* L., *Veronica jacquinii* Baumg., *Coronilla scorpioides* (L.) Koch, *Helianthemum nummularium* (L.) Miller subsp. *nummularium* (L.) Miller.

The grazed, ungrazed, cutted, and uncutted regions cover a 10 ha^{-1} area. Four permanent plots (20 m × 20 m) were established at 5 m distance in cutted and uncutted areas. Three sampling plots (20 m × 20 m) were selected in grazed and ungrazed areas. In each plot, five sampling quadrates (50 cm × 50 cm) were randomly selected and the distance between quadrants was at least 0.5 m from the margin to prevent edge effects in grazed and ungrazed areas (Dzwonko and Loster 1998; Li et al. 2011).

Some of the soil traits [soil EIVM (moisture), EIVR (soil reaction) and EIVN (soil nitrogen concentration)] were calculated from the analysis of soil samples. The results of soil analysis were adapted to Ellenberg's 1–9 (1–12 for moisture) scale. They were calculated between EIV plot averages and relevant environmental variables measured (Balković et al. 2012; Janišová et al. 2012). Ten soil samples were taken at a depth of 35 cm using a soil corer. The samples were then brought to the laboratory in polyethylene bags. After which the soil samples were air dried and sieved through a 2 mm mesh prior to analysis. Soil pH values were measured using deionised water (1:1). Soil nitrogen was determined by the way of micro-Kjeldahl method. Moisture was determined by the gravimetric method (Bayrakli 1987; Kutbay and Ok 2003). EIVL (light) was determined using a Lutron Light Meter LX-1102 (Schuster and Diekmann 2005). EIVT (temperature) values were calculated using original Ellenberg's scale (Pignatti et al. 2001).

The mean Grime's CSR values were determined using an Excel program (Grime et al. 1998; Grime 2002; Hodgson et al. 1999; Hüseyinova et al. 2013). Pierce et al. (2013) made some revisions on original Grime's classification due to some deficiencies in the determination of some criteria. For example, Grime's system is usually used for herbaceous species and the flowering period and flowering start may change phenologically. Accordingly, the species in the present study were also classified according to Pierce et al.'s (2013) classification scheme.

A cover-abundance value for each species in each plot was determined. Mean Ellenberg indicator values for light (L), nitrogen (N), soil pH (R), moisture (M), and temperature (T) were calculated for each quadrant using weighted average of each plot indicator values (Kasprowicz 2010; Spratt et al. 2011; Sürmen et al. 2014). EIVs were calculated using the weighted average formula:

$$\text{Weighted average} = \sum_{i=1}^{n} \left(r_{ij} \times x_i\right) / \sum_{i=1}^{n} r_{ij} \quad (1)$$

where 'r_{ij}' is the response of species, 'i' i. species in sample plot 'j', and 'x_i' is the indicator value of species 'i'.

Afterwards, the data were subjected to a PCA analysis to determine the species distribution along EIVs in grazed vs ungrazed and cutted vs uncutted areas. One-way ANOVA test was applied to find if there were significant differences among EIVs in grazed vs ungrazed and cutted vs uncutted areas. The data were also subjected to post hoc (Tukey's HSD) test for rank of the means (IBM Corporation 2012). Taxonomic nomenclature followed that of Guner et al. (2012).

3 Results

CR strategy was found to be the dominant in cutted and uncutted areas according to Grime's scheme, while S strategy was found to be the dominant one in cutted and uncutted areas according to Pierce et al.'s (2013) scheme (Tables 1, 2; Figs. 2, 3). The same results also found in the grazed and ungrazed areas (Tables 3, 4; Figs. 4, 5). Most species exhibit different strategies according to Grime's and Pierce et al.'s (2013) schemes. Only a few species exhibit similar strategy according to Grime et al. (1998) and Pierce et al. (2013) schemes. S-strategists were dominant according to Grime et al.'s (1998) scheme, while S/CSR-strategists were the dominant after cutting according to Pierce et al. (2013) scheme (Figs. 2, 3). Similarly, S-strategists become dominant according to Pierce et al.'s (2013) scheme, while CR strategists become dominant after grazing according to Grime et al.'s scheme (1998) (Figs. 4, 5).

All of EIVs were significantly different among areas (grazed vs ungrazed and cutted vs uncutted) and the grazed areas had the highest EIVs. However, EIVR values which were the highest in ungrazed and uncutted areas (Table 5). The highest EIVL values were found in grazed

Table 1 The species in cut areas according to Grime et al.'s and Pierce et al.'s schemes

Cutted	Grime's scheme	Pierce et al.'s scheme
Arbutus andrachne L.	SC	S
Quercus hartwissiana Steven	C/SC	S/CS
Quercus petraea (Mattuschka) Liebl.	C	S/CSR
Amelanchier rotundifolia (Lam). Dum.-Courset	SC	S
Jasminum fruticans L.	C/SC	S/SR
Phillyrea latifolia L.	SC	S
Cistus creticus L.	SC	S
Rosa canina L.	SC	S/CS
Juniperus foetidissima	S/SC	S
Erodium ciconium (L.) LÂ´HERIT.	CR	CR/CSR
Polygala pruinosa Boiss. subsp. *pruinosa* Boiss.	R/CR	R
Helianthemum nummularium (L.) Miller subsp. *nummularium* (L.) Miller	S/SR	S
Veronica jacquinii Baumg.	SC/CSR	S/SR
Globularia trichosantha Fisch	SC/CSR	S
Coronilla scorpioides (L.) Koch	R/CR	R/CR
Vicia narbonensis L.	CR	CR/CSR
Holosteum umbellatum L.	CR	C/CR
Tragopogon coloratus C. A. Meyer	CR	C/CSR
Ophrys mammosa Desf.	R/CR	CR
Reseda lutea L. var. *lutea* L.	CR	CR/CSR
Raphanus raphanistrum L.	C/CR	R/CSR
Cerasus mahaleb (L.) Miller var. *mahaleb* (L.) Miller	C	S/CSR
Quercus cerris L.var. *cerris* L.	C/SC	S/CSR
Pistacia terebinthus L.	C	CS
Clematis viticella L.	C	S/CSR
Scutellaria salviifolia Bentham	C/CS	S
Colutea arborescens L.	C	S/CSR
Cardaria draba (L.) Desv. subsp. *draba*	C/CR	S/CSR
Cruciata taurica (Pallas ex Willd.) Ehrend.	S	S/SR
Galium aparine L.	CR	S/SR
Erysimum goniocaulon Boıss.	CR	SR
Tripleurospermum parviflorum (Wılld.) Pobed.	SC	SR
Centaurea depressa Bieb.	CR	SR/CSR

areas, while the lowest EIVL values were found in uncutted areas (Fig. 6). EIVM values ranged from 2.52 to 4.98 in ungrazed areas, while they ranged from 11.27 to 15.65 in grazed areas (Fig. 7). EIVM values ranged from 1.78 to 2.08 and 2.80 to 4.98 in cutted and uncutted areas, respectively (Fig. 7). EIVN values were from 0.66 to 0.72 in grazed areas, while 0.13 to 0.19 in ungrazed areas. EIVN values ranged from 0.59 to 0.62 and 0.66 to 0.72 in cutted and uncutted areas, respectively (Fig. 8). The differences in EIVR values were very small, however, the highest and the lowest EIVR value was found in the grazed and cutted areas, respectively (Fig. 9). EIVT values ranged from 2.98 to 3.01 in cutted areas, and 3.95 to 4.21 in uncutted areas. EIVT values ranged from 2.94 to 3.12 and 4.85 to 5.23 in

Table 2 The species in uncutted areas according to Grime et al.'s and Pierce et al.'s schemes

Non-cutted	Grime's scheme	Pierce et al.'s scheme
Arbutus andrachne L.	C/SC	S/CS
Quercus hartwissiana Steven	C/SC	S/CS
Quercus petraea (Mattuschka) Liebl.	C	S/CSR
Amelanchier rotundifolia (Lam). Dum.-Courset	C/SC	S
Jasminum fruticans L.	C/SC	S
Phillyrea latifolia L.	C/SC	S
Cistus creticus L.	C/CS	S/CS
Rosa canina L.	C	S/CS
Juniperus oxycedrus L.	SC	S
Erodium ciconium (L.) LÂ´HERIT.	CR	CS
Globularia trichosantha Fısch.	SC	S
Helianthemum nummularium (L.) Miller subsp. *nummularium* (L.) Miller	CR	S/SR
Veronica jacquinii Baumg.	CR	CSR
Globularia trichosantha Fısch.	SC	S
Coronilla scorpioides (L.) Koch	CR/CSR	S/CSR
Vicia narbonensis L.	CR	SR/CSR
Adonis aestivalis L. subsp. *aestivalis* L.	CR	S
Euphorbia rigida Bieb.	SC	S
Marrubium vulgare L.	SC	S
Ajuga chamaepitys (L.) Schreber subsp.*chia* (Schreber) arcangeli var. *chia*(Schreber) arcangeli	SR/CSR	S/SR
Euphorbia szovitsii Fisch. Et Mey.	CR	SR/CSR

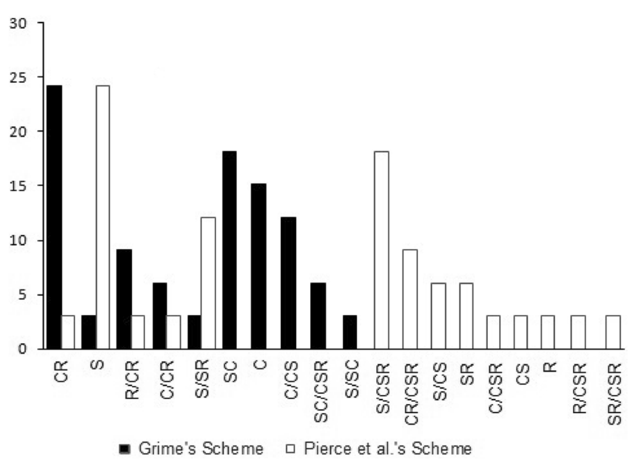

Fig. 2 The classification of the species according to Grime et al.'s and Pierce et al.'s schemes in cutted areas (*X*-axis: ecological strategies; *Y*-axis: the number of species belonging to a particular strategy)

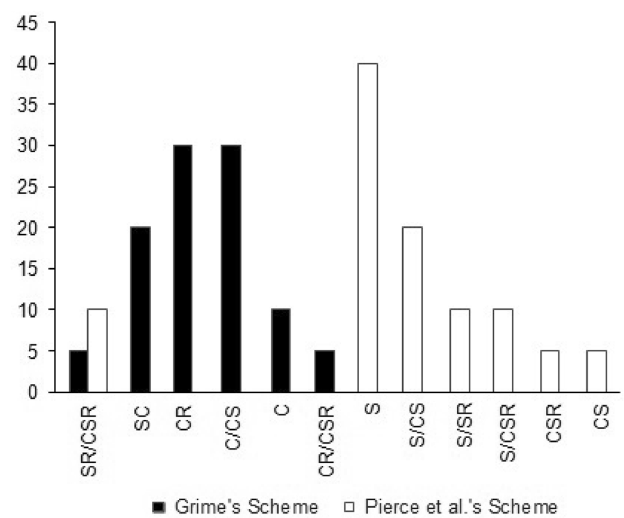

Fig. 3 The classification of the species according to Grime et al.'s and Pierce et al.'s scheme in uncutted areas (*X*-axis: ecological strategies; *Y*-axis: the number of species belonging to a particular strategy)

ungrazed and grazed areas, respectively (Fig. 10). In grazed areas, EIVF, EIVL, EIVN, and EIVT values were found to be high, while in the cutted areas EIVR values were found to be high. The lowest EIVF and EIVT values were found in cutted areas, while the lowest EIVL and EIVR values were found in uncutted areas. Ungrazed areas had the lowest EIVN values. Ellenberg's *L* and *R* values were found to be high, while *F* and *T* values were at the mean range.

Table 3 The species in grazing areas according to Grime et al.'s and Pierce et al.'s schemes

Grazed	Grime's scheme	Pierce et al.'s scheme
Achillea setacea Waldst. et Kit	CR/CSR	S/SR
Ajuga chamaepitys (L.) Schreber subsp. *chia* (Schreber) arcangeli var. *ciliata* Briq.	S	S
Anchusa azurea Mill. var. *azurea*	CR	C/CS
Adonis aestivalis L. subsp. *aestivalis* L.	CR	R/CR
Scutellaria orientalis L. subsp. *pinnatifida Edmondson*	S/SR	S
Alopecurus arundinaceus Poiret	CR	R/CSR
Anthemis melanoloma Trautv.	CR/CSR	S/SR
Aristolochia clematitis L.	CR	SR/CSR
Astragalus melanophrurius Boiss.	C/CR	R/CR
Cardaria draba (L.) Desv. subsp. *draba*	CR/CSR	S/SR
Astrodaucus orientalis (L.) Drude	CR	CS/CSR
Erodium ciconium (L.) LÂ´HERIT.	R/CR	CR
Bromus japonicus Thunb.	CR	R/CSR
Fumaria asepala Boiss.	R/CR	R/CR
Galium aparine L.	CR/CSR	R
Galium tricornutum Dandy	R/CR	R/SR
Carduus pycnocephalus L. subsp. *albidus* (Bieb.) Kazmı	CR	C/CR
Geranium pusillum Burm. Fil.	R/CR	R
Helianthemum salicifolium (L.) Miller	SC	SR
Carpinus orientalis Miller	SC	S/CS
Centaurea amasiensis Bornm	CR	R/CR
Lathyrus aphaca L.	S/SC	S
Cerastium chlorifolium Fisch. et Mey.	CR	S
Cerinthe minor L. subsp. *auriculata* (Ten.) Domac	R/CR	C
Chaerophyllum angelicifolium Bieb.	CR	C/CR
Cistus creticus L.	S	S
Clinopodium vulgare subsp. *arundanum*	R/CR	R
Convolvulus assyricus Griseb.	SR/CSR	S/SR
Cruciata taurica (Pallas Ex Willd.) Ehrend	R/CR	R
Pistacia terebinthus L. subsp. *palaestina* (Boiss.) Engler	SC	S/CS
Fumaria densiflora DC.	R/CR	R/CR
Geranium macrostylum Boiss.	S	S
Globularia trichosantha Fisch	SC	S
Helianthemum nummularium (L.) Miller *subsp. nummularium* (L.) Miller	R/CR	SR/CSR
Hordeum bulbosum L.	CR	R
Hordeum murinum L. subsp. *glaucum* (Steudel) Tzvelev	SC/CSR	R/SR
Juniperus oxycedrus L.	S/SC	S
Lamium orientale (Fisch. & C.A.Mey.) E.H.L.Krause	CR	CSR
Senecio vernalis Waldst. Et Kit.	S/SC	S/CS
Marrubium vulgare L.	S	S
Muscari comosum (L.) Miller	CR	C
Nonea macrosperma Boiss. Et Heldr.	CR	C
Phillyrea latifolia L.	S/SC	S
Plantago lanceolata L.	R/CR	CR
Plantago scabra Moench	R/CR	R/CR
Poa trivialis L.	S/SC	S/SR
Ranunculus dissectus Bieb. subsp. *sibthorpii* Davis	CR	R/CSR
Ranunculus domascenus Boiss.&Gaill.	C/CR	C/CS

Table 3 (continued)

Grazed	Grime's scheme	Pierce et al.'s scheme
Ranunculus repens L.	R/CR	CR
Roemeria hybrida (L.) Dc. subsp. *hybrida*	CR	CR/CSR
Silene alba (Miller) Krause subsp. *eriocalycina* (Boiss.) Walters	CR	CR
Stellaria holostea L.	CR	R
Thlaspi arvense L.	SC	S
Torilis leptophylla (L.) Reiche	CR	S/CS
Tragopogon coloratus C. A. Meyer	CR	R/SR
Trifolium hybridum L. var. *anatolicum* (Boiss.) Boiss.	CR	R/CSR
Valeriana pumila Willd.	SC	C
Veronica jacquinii Baumg.	SC	S/SR
Vicia sativa L. subsp. *sativa* L.	CR	CR
Viola sieheana Becker	R/CR	R/CR

Species and environment scores in canonical axis 1 and 2 were found to be significant. Eigenvalues were explained 80 and 91% of the cumulative variance, respectively. Ellenberg's *M*, *R*, and *T* values were found to be significant on axis 1, while Ellenberg's *L*- and *N*-values were found to be significant on axis 2 (Table 6). According to PCA diagram, EIVR was situated on the positive site, while EIVL, EIVM, EIVN and EIVT were situated on the negative site of the PCA diagram. Ungrazed and cutted areas were associated with EIVR, while grazed and uncutted areas were associated with EIVL, EIVM, EIVN and EIVT (Fig. 11).

4 Discussion

There were some inconsistencies between Grime et al. (1998) and Pierce et al.'s (2013) schemes. For example, according to Pierce et al.'s (2013) scheme pure R-strategists were represented, while R-strategists were not represented after cutting and grazing according to Grime et al. (1998) scheme. Ruderal strategists are also called "colonists". They are characterized by rapid germination, short life cycle, early flowering and for allocating many of their resources to reproduction and are very resistant to disturbance factors such as grazing. R-strategists usually colonize in bare areas due to the abundance of microsites (Pywell et al. 2003). It has been reported that there is a close relationship between competition and disturbance tolerance (Xu et al. 2016). As a result of all of these factors, R-strategists represented with a high proportion in disturbed areas. Similarly, pure C-strategy was found in grazed and ungrazed areas according to Grime et al.'s (1998) scheme, while C-strategy was not found in both cutted and uncutted areas according to Pierce et al.'s (2013) scheme. Pure C-strategy was also represented before and after cutting according to Grime et al.'s (1998) scheme. Moog et al. (2005) reported that C-strategists were found in grazed areas and this is in accordance with the moderate grazing favored species with intermediate levels of competitiveness, stress tolerance and rurality. The cutting of trees does not suffice in maintaining homogeneous and species-rich grassland communities. As a result permanent grazing gaps are formed and grassland species are recolonized (Dzwonko and Loster 1998). *Quercus petraea* (Mattuschka) Liebl., *Cerasus mahaleb* (L.) Miller *var. mahaleb* (L.) Miller, and *Colutea arborescens* L. exhibit C-strategy in the study area. These species are canopy species and have a good ability to receive light as compared to subcanopy species. Niche complementarity increased with an increase in the competition for light (Chai et al. 2016).

It has been found that the number of S-strategists increased after grazing according to Pierce et al.'s (2013) scheme, while the number of S-strategists decreased in

Table 4 The species in ungrazed areas according to Grime et al.'s and Pierce et al.'s schemes

Ungrazed	Grime's scheme	Pierce et al.'s scheme
Onosma frutescens Lam.	CR	C
Ajuga chamaepitys (L.) SCHREBER subsp.*chia* (SCHREBER) ARCANGELI var. *chia*(SCHREBER) ARCANGELI	R/CR	C
Anchusa azurea Mill. var. *azurea*	CR	C/CR
Avena barbata Pott ex Lınk subsp. *barbata* Pott Ex Link	C/SR	R/CR
Avena eriantha Durieu	SC	S
Avena sterilis L.	CR	SR/CSR
Beta lomatogona Fisch. & C.A.Mey.	C/CR	C
Calepina irregularis (Asso) Thell.	CR	C
Capsella bursa-pastoris (L.) Medik.	CR	S
Cardaria draba (L.) Desv. subsp. *draba*	C/CR	CS
Crataegus monogyna Jacq. subsp. *monogyna* Jacq.	C/SC	S
Erodium ciconium (L.) LÂ´HERIT.	CR	C/CR
Fibigia eriocarpa (Dc.) Boiss.	C/CR	CR/CSR
Fumaria asepala Boiss.	CR	R/CR
Galium aparine L.	CR	R
Galium tricornutum Dandy	CR	CR
Geranium purpureum Vill.	C/CR	CSR
Geranium pusillum Burm. Fil.	CR	C/CS
Helianthemum salicifolium (L.) Miller	SC	S
Hordeum vulgare L.	SC/CSR	SR/CSR
Lamium amplexicaule L.	R/CR	CR
Lathyrus aphaca L.	CR	R
Malva sylvestris L.	C/CR	CR/CSR
Matricaria chamomilla L. var. *recutita* (L.) Grierson	CR	CR
Mentha longifolia (L.) L.	CR	CR/CSR
Onosma bornmuelleri Hausskn.	CR	S/CS
Papaver lacerum Popov	C/CR	C/CS
Papaver rhoeas Linn	C/CS	CS
Pistacia terebinthus L	C	S/CSR
Plantago lanceolata L.	R/CR	C/CR
Ranunculus ficaria L. subsp. *calthifolius* (Reichb.) Arc.	CR	R/CR
Rhamnus oleoides L.	C/SC	S
Rubus canescens Dc. var. *canescens* Dc.	C	CS/CSR
Sanguisorba minor Scop.	C/CR	CS
Scandix pecten-veneris L.	SC	S
Scrophularia canina L. subsp. *bicolor* (Sm.) Greuter	CR	CR
Senecio mollis Willd.	R/CR	C/CR
Senecio vernalis Waldst. & Kit.	R/CR	C
Silene vulgaris (Moench) Garcke. var. *vulgaris*	CR	C/CR
Sinapis arvensis L.	CR	C
Sisymbrium orientale L.	C/CR	CS
Solanum dulcamara L.	C/CR	CSR
Stachys annua (L.) L. subsp. *annua* (L.) L. var. *bycaonica* Bhattacharjee	CR	CSR
Taraxacum officinale (L.) Weber ex F.H.Wigg.	R/CR	C
Urtica dioica L.	CR	C/CSR
Vicia cracca L. subsp. *cracca* L.	C/CR	SR

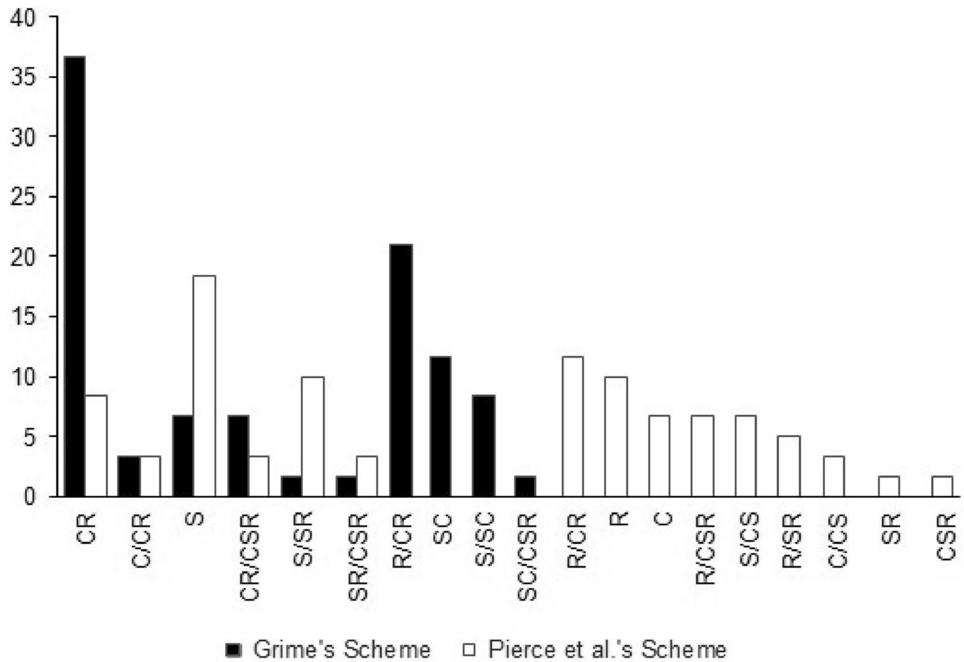

Fig. 4 The classification of the species by Grime et al.'s and Pierce et al.'s scheme in grazed areas (*X*-axis: ecological strategies; *Y*-axis: the number of species belonging to a particular strategy)

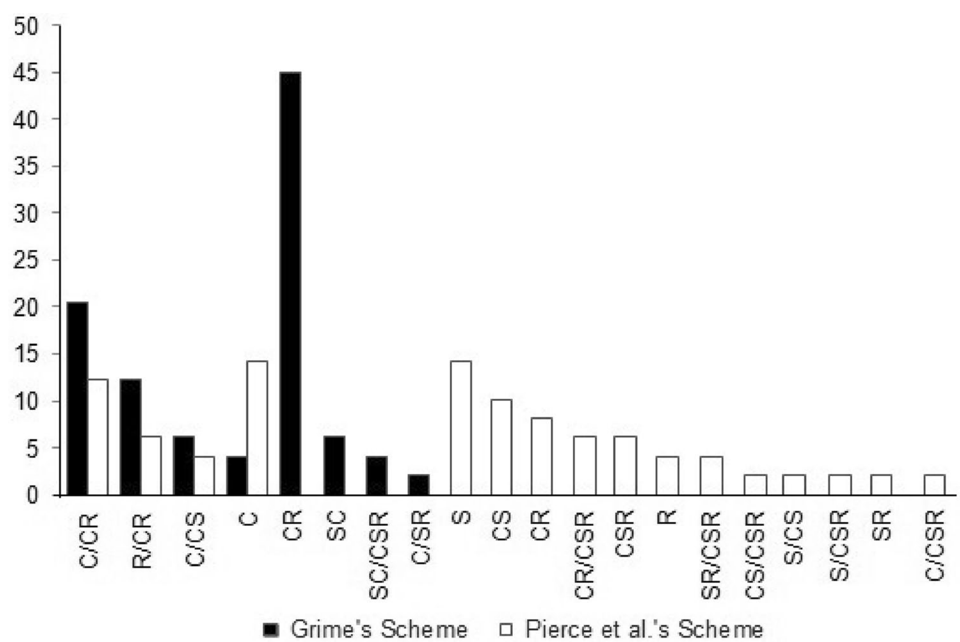

Fig. 5 The classification of the species according to Grime et al.'s and Pierce et al.'s scheme in ungrazed areas (*X*-axis: ecological strategies; *Y*-axis: the number of species belonging to a particular strategy)

Table 5 Statistical evaluation of EIVs by One-way ANOVA test

	Disturbance factor					Significance
	Grazed	Ungrazed	Ungrazed 2	Cutted	Uncutted	
EIVM	13.34a	2.67bc	4.13b	1.85c	2.80bc	0.001
EIVL	8.97a	8.02b	–	8.00b	6.98c	0.000
EIVN	0.67a	0.15d	–	0.60c	0.64b	0.001
EIVR	7.30c	7.79ab	–	7.74b	7.85a	0.001
EIVRT	5.03a	3.01c	–	2.99c	4.07b	0.000

Means followed by the different letter in the same line are significantly different at the 0.05 level according to Tukey's HSD test

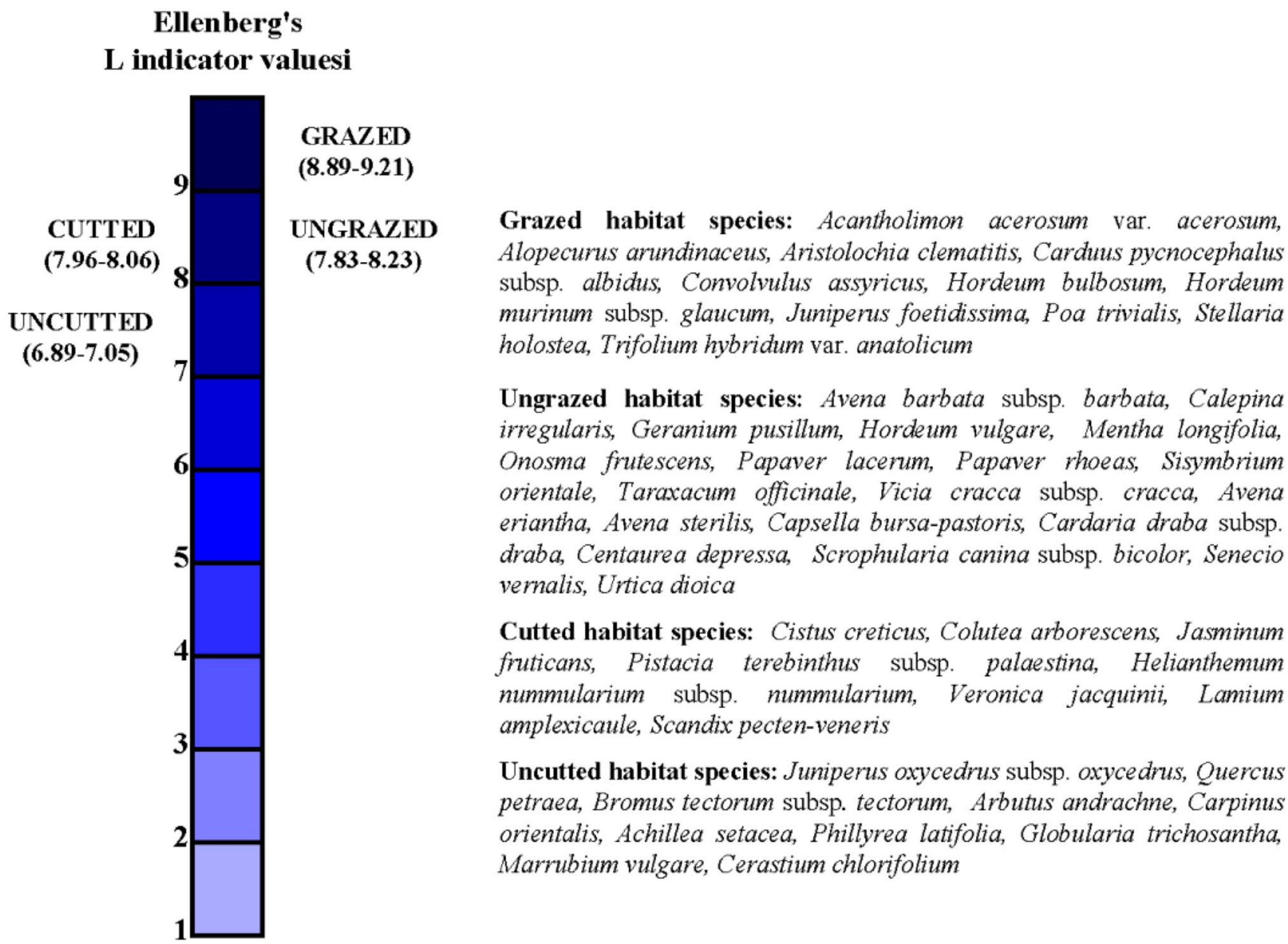

Fig. 6 Ellenberg's light (EIVL) indicator values in the study area

cutted areas and shifted to secondary S-strategists. Stress-tolerant (S) strategists are resistant to nutrient deficiency and they are able to survive under dry conditions. They also adapted to harsh conditions with their long-lasting organs and reproduction occurs during the end of growing season (Hellström et al. 2003; Pywell et al. 2003). The increase of S-species through grazing may also be a competitive advantage under nutrient stress or the possession of defensive structures (Moog et al. 2005). Negreiros et al. (2014) indicated that unproductive environments favor the species with traits typical of stress-resistance syndrome. Disturbance factors (i.e. cutting and grazing) caused an increase in landscape heterogeneity and habitat fragmentation (Vukovic et al. 2014). According to Pierce et al.'s (2013) scheme, S-strategists were dominant in grazed and uncutted areas and these species also had high EIVN values. Franzaring et al. (2007) found that Ellenberg's *N*-indicator values are well matched with S-strategists. Grime et al.'s (1998) stated that competitive ruderal (CR) strategists were found to be dominant in both grazed vs. ungrazed and cutted vs. uncutted areas. CR species includes annual and short-lived perennial species. These species completed their life-cycle rapidly and are more resistant to the effects of disturbance (Pierce et al. 2007; Škornik et al. 2010; Hüseyinova et al. 2013).

It has been found that CSR strategies were different when different schemes were used. Pierce et al. (2013) found that the strategies of individuals may be rather different and such differences may lead to the formation of ecotypes

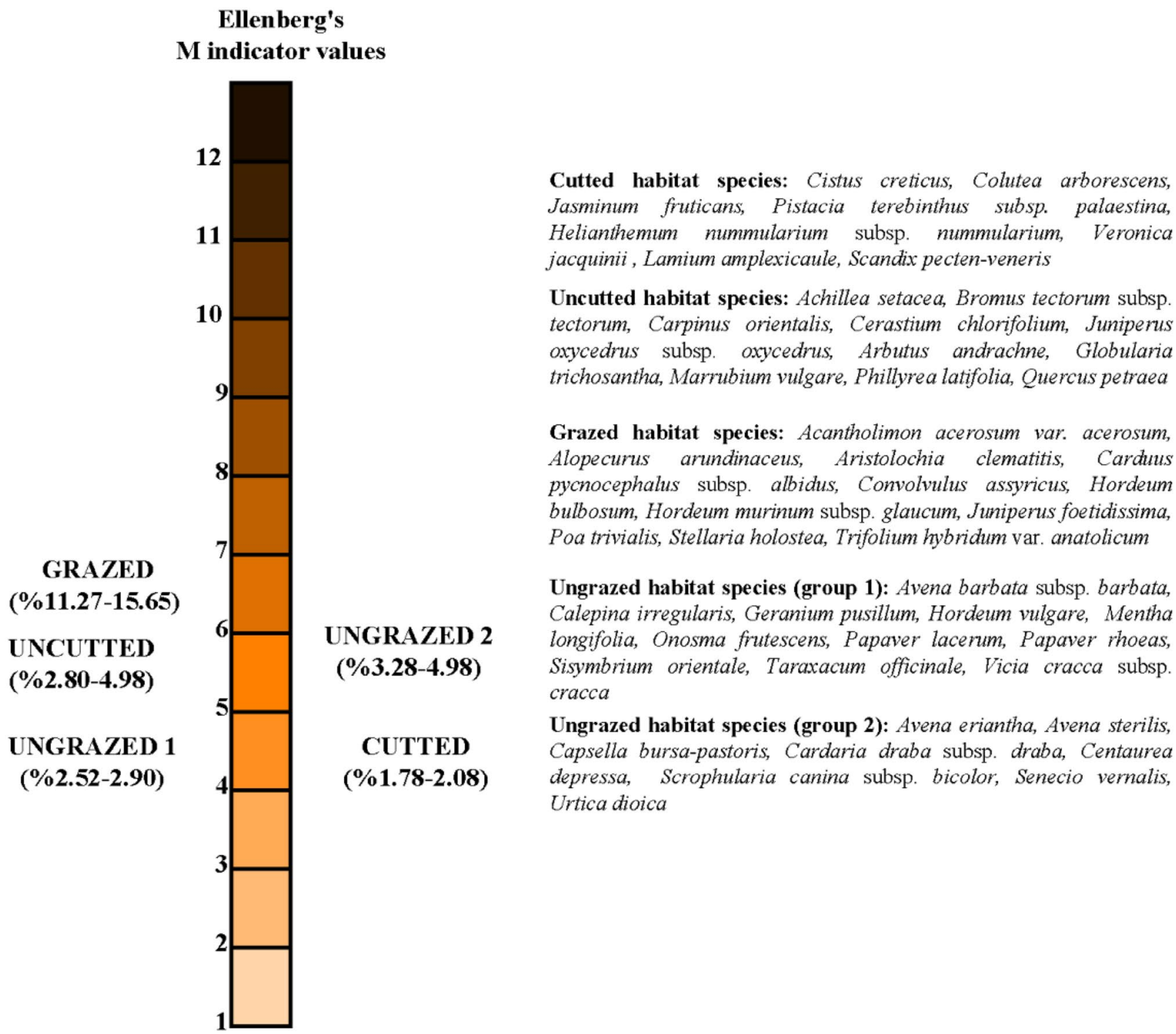

Fig. 7 Ellenberg's moisture (EIVM) indicator values in the study area

under harsh disturbance factors such as grazing and cutted. They reported that *Bromus* species exhibit S/SC strategy, while *Bromus* species exhibit R/CR strategy according to Grime et al.'s (1998) scheme. In the present study, *Bromus japonicus* exhibit R/CSR strategy according to Pierce et al.'s scheme (2013), while this species exhibits CR strategy according to Grime et al.'s (1998) scheme. Such differences may be originated some criteria in Grime's system were omitted in Pierce et al.'s scheme (2013). Numerical traits were used in Pierce et al.'s (2013) scheme and changeable ones such as flowering period and flowering time were omitted. We emphasized that the using of Pierce et al.'s scheme in the classification of species subjected to disturbance factors is more practical because numerical criteria were used.

Our data showed that EIVM, EIVT, EIVL, and EIVN values were found to be high in grazed areas. Plassmann

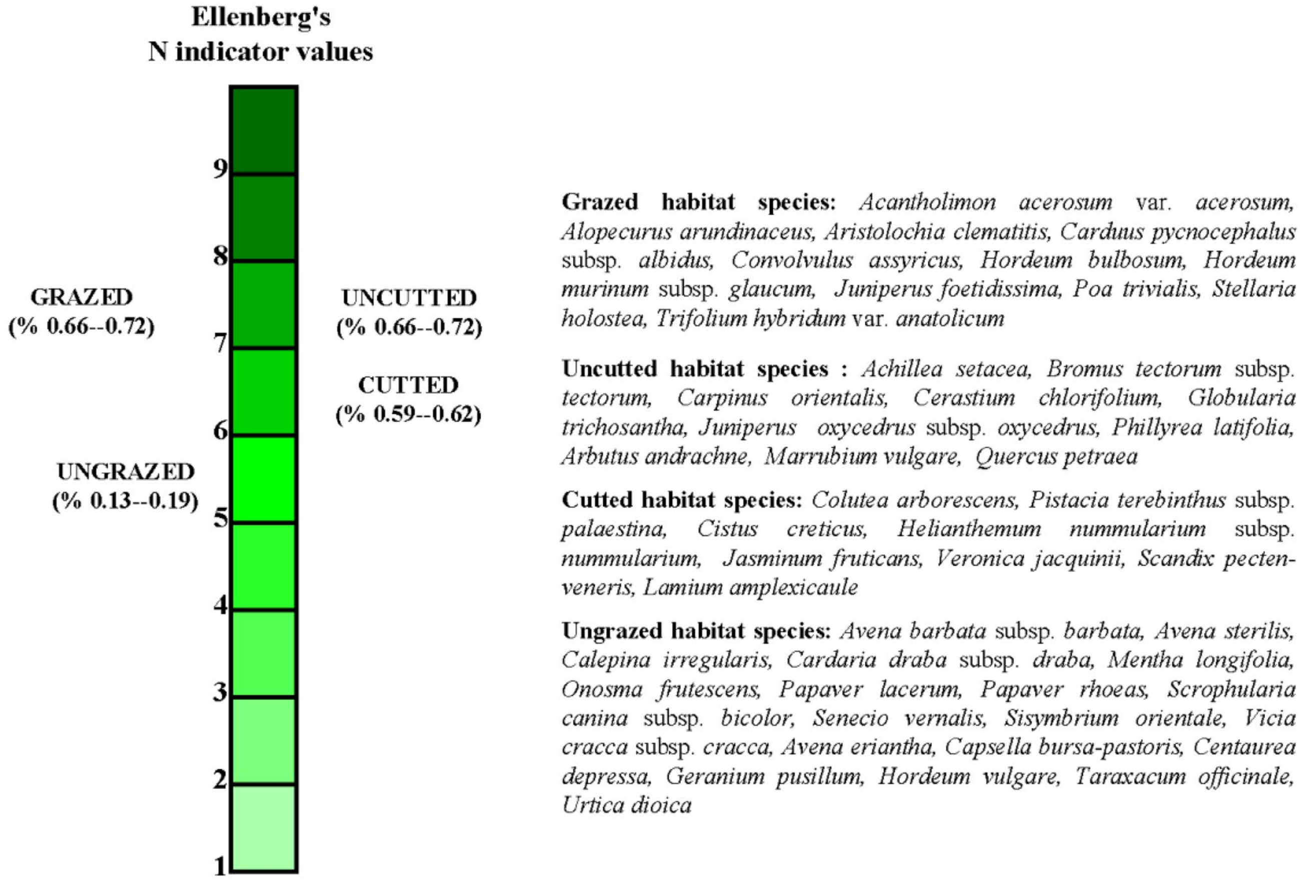

Fig. 8 Ellenberg's nitrogen (EIVN) indicator values in the study area

et al. (2010) found that EIVM and EIVN were high in grazed areas and they also stated that EIVN values are more important in interpreting the general productivity of an ecosystem than mere soil nitrogen concentrations (Bartelheimer and Poschlod 2016). In ungrazed areas, Ellenberg's *N*-indicator values were found to be low- and stress-tolerant (S) strategists were represented with a high proportion in ungrazed areas according to Pierce et al.'s (2013) scheme. Pontes et al. (2015) stated that stress-tolerant species were able to persist and cope with local nutrient shortages. It was found that grazed areas had the highest *N* values, while ungrazed areas had the lowest *N* values and ungrazed areas were occupied by annual herb species such as *Calepina irregularis*, *Avena sterilis*, and *Centaurea depressa*. Li et al. (2011) reported that grazing might have a potentially positive effect in increasing the soil *N* storage. Since a high-nitrogen concentration was determined in grazed ecosystems (Tardella et al. 2016).

EIVL values were found to be highest in grazed areas. *L*-indicator values were found to be highest in grazed areas, while they were lowest in uncutted areas. Plassmann et al. (2010) stated that grazing causes an increase of EIVL because a high competition for light occurs among the species in the grazed areas. Competition for light is of particular importance during longer periods of insufficient light (Pykälä 2005; Tardella et al. 2016; Bartelheimer and Poschlod 2016).

Mediterranean shrubs such as *Cistus creticus*, *Colutea arborescens*, *Jasminum fruticans*, *Pistacia terebinthus* subsp. *palaestina*, had the lowest EIVM values. Mediterranean species typically had low EIVM values and they are usually subjected to high summer drought stress and they competed with each other for light (Tardella et al. 2016).

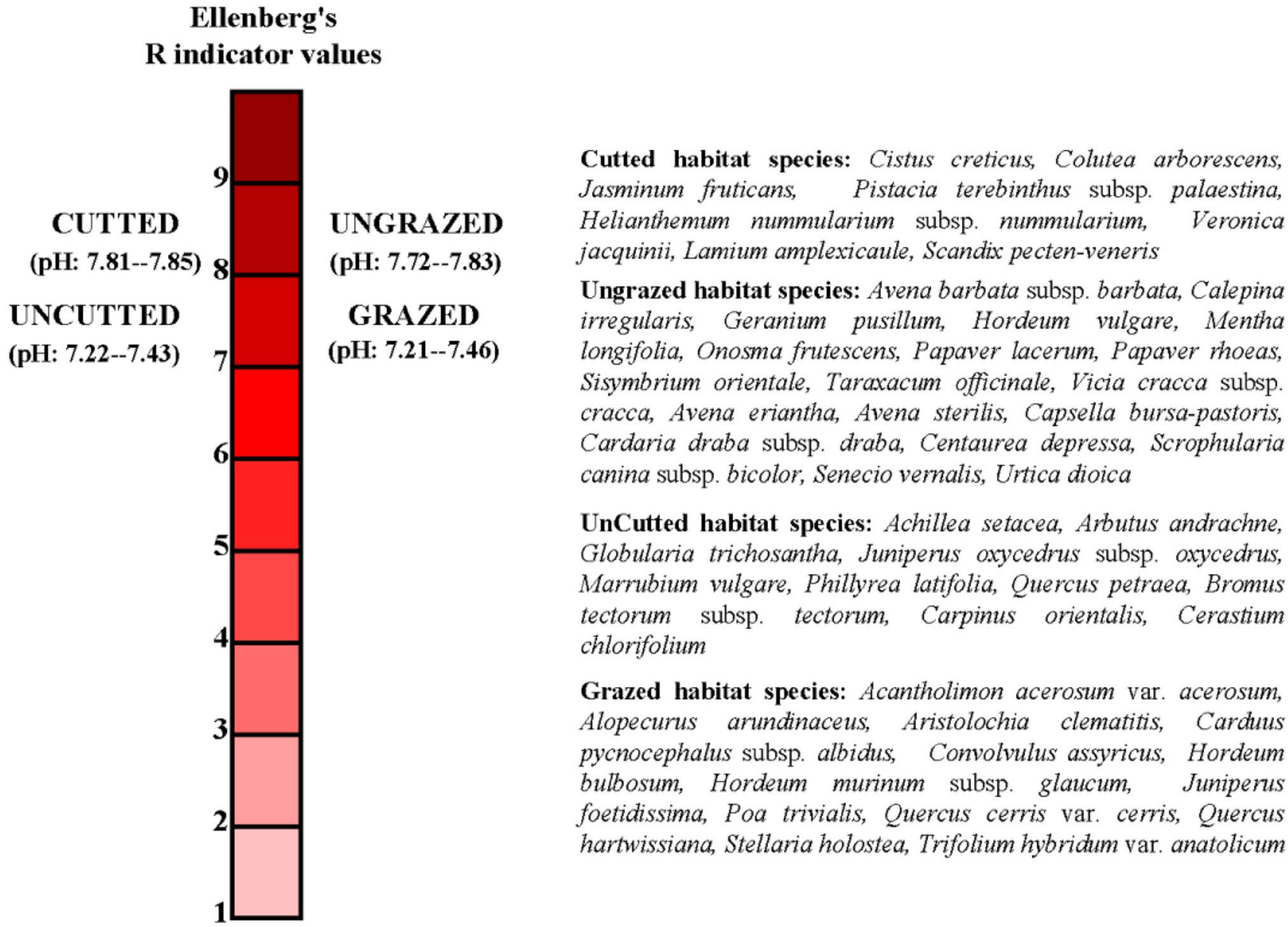

Fig. 9 Ellenberg's soil reaction (EIVR) indicator values in the study area

Uncutted and grazed areas are occupied by tree and shrub species such as *Carpinus orientalis*, *Juniperus oxycedrus* subsp. *oxycedrus*, *Phillyrea latifolia*, *Arbutus andrachne*, *Quercus petraea*, *Juniperus foetidissima*, *Quercus cerris* var. *cerris* and *Quercus hartwissiana* and they had high EIVN values, while grazed habitat species occupied by *Acantholimon acerosum* var. *acerosum*, *Juniperus foetidissima*, *Quercus cerris* var. *cerris* and *Quercus hartwissiana* which had the highest EIVM values. Temporal niche partitioning was ensured by species with rhizomes and green leaf persistence. Unpalatability was related to low *N* and *M* values. It especially occurred in the ungrazed habitat with species such as *Onosma frutescens*, *Papaver lacerum*, *Papaver rhoeas*, *Scrophularia canina* subsp. *bicolor*, *Senecio vernalis*, *Centaurea depressa*, *Geranium pusillum*, *Urtica dioica* since they had low *N* and cutted habitat with species such as *Cistus creticus*, *Colutea arborescens*, *Jasminum fruticans*, *Pistacia terebinthus* subsp. *palaestina*, *Helianthemum nummularium* subsp. *nummularium*, *Veronica jacquinii*, and *Lamium amplexicaule* which had low *M* values. All of these species are fast growing and they have low palatability (Tardella et al. 2016).

Opposite results were found regarding EIVR values and disturbance factors. Some studies showed that undisturbed areas had high EIVR values, while other studies showed disturbed areas had high EIVR values. For example, Ellenberg's EIVR values were found to be high in ungrazed habitats (Spiegelberger et al. 2006). Ungrazed areas were found to be positively associated with EIVR values in the present study. However, Kohyani et al. (2008) found that

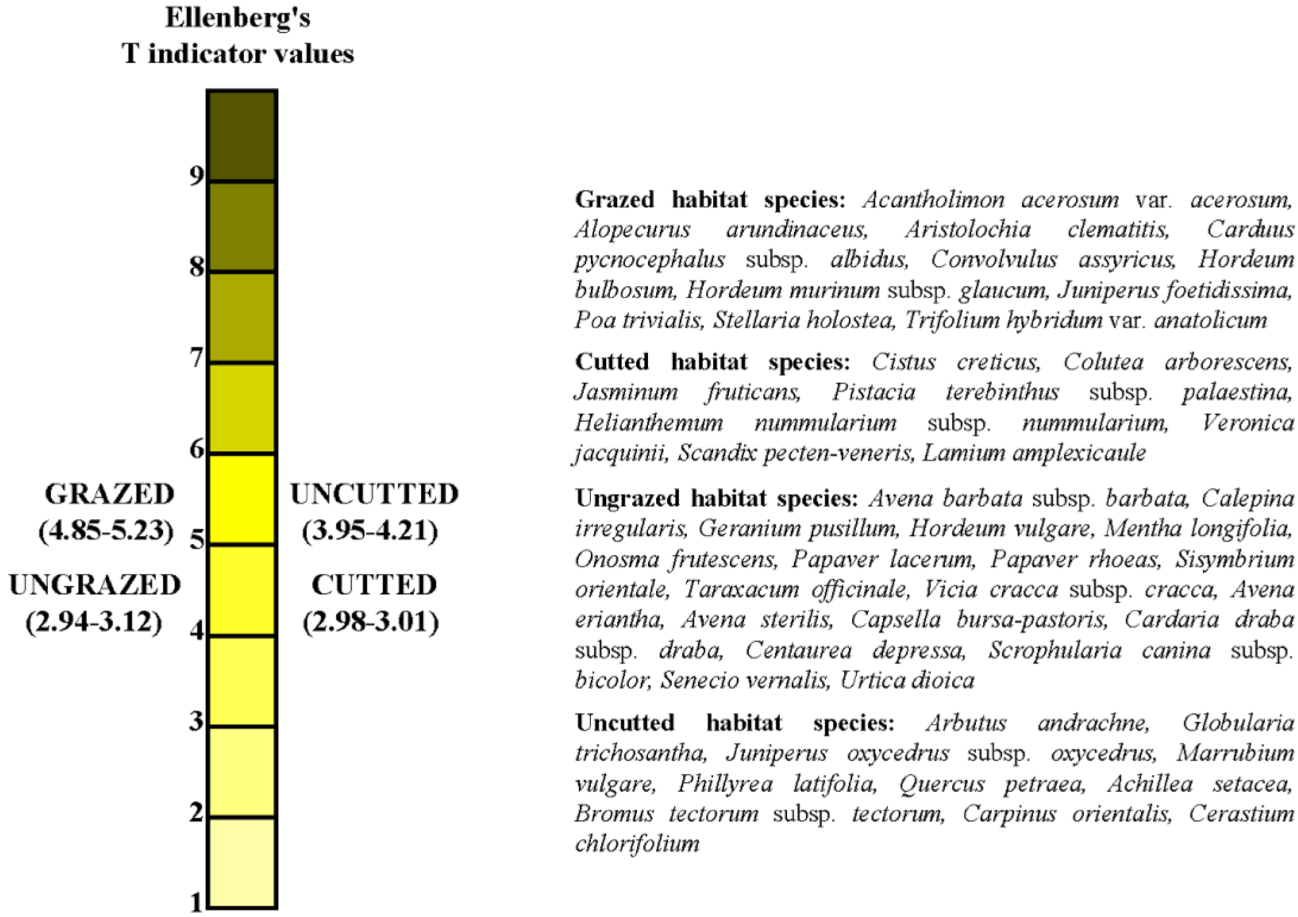

Fig. 10 Ellenberg's temperature (EIVT) indicator values in the study area

Table 6 Eigenvaues for EIVs

EIVs	Axis 1	Axis 2
L	**– 0.41**	**0.46**
M	**– 0.47**	0.15
N	– 0.37	**– 0.85**
R	**0.48**	– 0.15
T	**– 0.48**	– 0.03

Significant values were indicated by using bold character

disturbed areas had high EIVR values. Similarly it has been found that cutted areas had the highest EIVR values in the present study.

The dominance of secondary strategies indicated that stress and disturbance are at intermediate levels in a particular area according to "intermediate disturbance hypothesis" (Martín-García et al. 2016). Our results were agreed with "intermediate disturbance hypothesis" because secondary strategies were found to be widespread in grazed vs ungrazed and cutted vs uncutted areas. Significant differences were found between grazed vs ungrazed and cutted vs uncutted areas regarding EIVs. EIVs reflect the relation between each species and environmental factors, and management practices and they integrate species behavior even over several years (Duru et al. 2013). Grime's CSR system is also helpful for the optimization of management methods in disturbed areas (Bakker et al. 2002; Hellström et al. 2003; Pykälä 2005) but Pierce et al.'s scheme is a bit more practical due to the using of numerical criteria. Therefore,

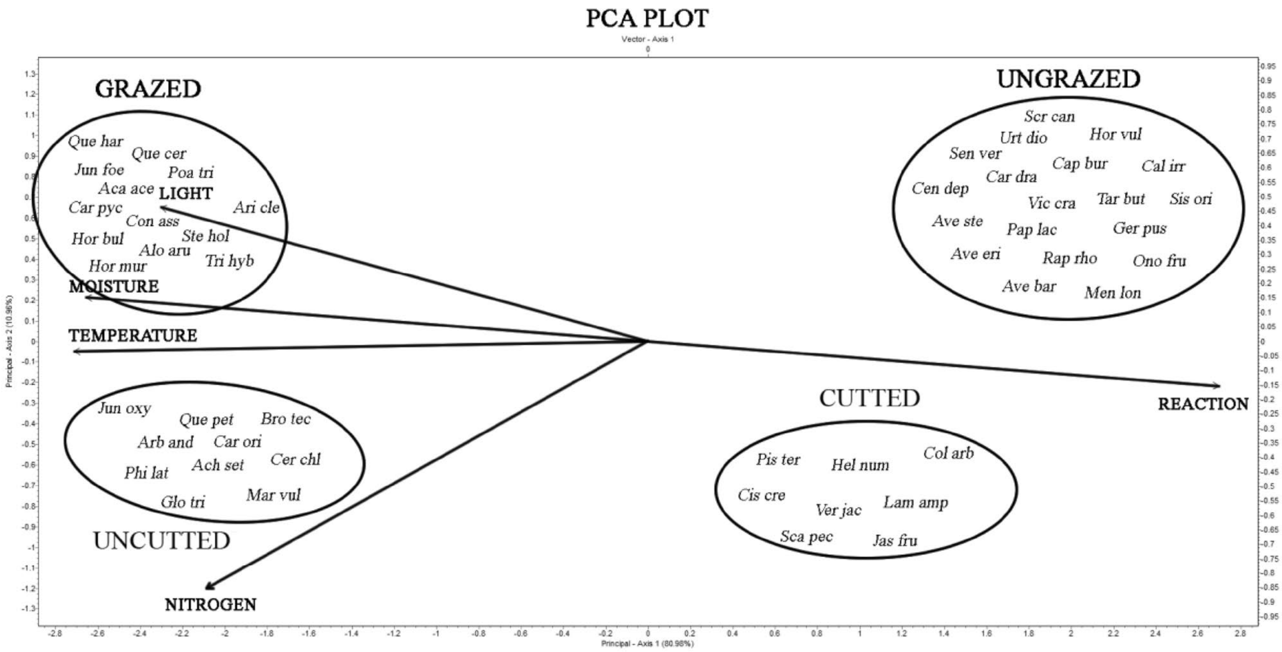

Fig. 11 The relationships among EIVs and disturbance factors by principal component analysis (PCA) in the study area

the results of the present study may be applied to disturbed areas for a sustainable management planning.

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