Effectiveness of GAEC cross-compliance Standard 4.2c for biodiversity conservation in set-asides, part II (ground-dwelling Arthropods and Vertebrates)

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Abstract

The MO.NA.CO. project has been set up to evaluate the effectiveness of some GAECs (Good Agricultural and Environmental Conditions) through the institution of a monitoring network throughout the Italian territory. The present work deals with the evaluation of the Standard 4.2c, concerning biomass and biodiversity in set-asides, in relation to fauna conservation. Monitoring was performed in three areas, using the following indicators: ground-dwelling Arthropods identified at the order level, Coleoptera identified at the family level and Lacertids. Our results seem to indicate that a mild management of set-asides, consisting in mowing once a year (mid July in the examined areas), may enhance faunal diversity, above all Arthropod diversity. After mowing, the set-asides managed following Standard 4.2, hosted higher levels of Arthropod diversity and a more balanced faunistic composition in comparison to unmoved set-asides and arable lands. On the contrary, we did not find significant effects of mowing on lizard abundance. We also discussed some measures to mitigate the negative direct effects of mechanical mowing on fauna.

Introduction

Since 2003-2004 the Common Agricultural Policy (CAP) has introduced a new concept of rural development involving environmental conservation. In the same perspective, the following CAP 2007-2013 and 2014-2020, included among their principal aims the preservation of environment and the sustainability of rural landscapes. Such objectives have been promoted through a policy of financial supports under cross compliance. «*Cross-compliance is a mechanism that links direct payments to compliance by farmers with basic standards concerning the environment, food safety, animal and plant health and animal welfare, as well as the requirement of maintaining land in good agricultural and environmental condition*» (http://ec.europa.eu/agriculture/envir/cross-compliance/index_en.htm). Standards pursuing the same objectives are arranged in Good Agricultural and Environmental Conditions (GAECs).

The MO.NA.CO. project (national network for monitoring the environmental effectiveness of cross compliance and the differential of competitiveness charged against agricultural enterprises) has been set up with the aim of evaluating the effectiveness of some GAECs through the institution of a monitoring network throughout the Italian territory. The Zoological Section of the Natural History Museum of the University of Florence, took part in the project evaluating the effectiveness of three standards for animal diversity conservation (Corti *et al*., 2015). This work shows the evaluation of Standard 4.2c, dealing with biomass and biodiversity in set-asides, in relation to fauna conservation. The presence of set-asides in agricultural landscapes can represent a key resource for biodiversity, enhancing landscape heterogeneity and supplying fauna with refuge areas, with lower disturbance levels (Benton *et al*., 2003; van Buskirk and Willi, 2004; Biaggini *et al*., 2011). Following GAEC requirements, set-asides should be mowed at least once a year, with respect to the seasonal ban established by EC 73/2009; in this project we monitored the possible effects of mowing regimes on biodiversity. Monitoring was performed using different taxa as indicators: ground-dwelling Arthropods, identified at the order level, Coleoptera identified at the family level and, among Vertebrates, Lacertids and Birds (results about Birds are not presented here). Given the complexity of the concept of biodiversity, we choose taxa with very different ecological requirements to perform a more complete evaluation of the Standard. In particular, Arthropods are most frequently used as bio-indicators in agriculture, their reliability is ascertained and their use can allow useful comparisons with data reported in literature. Reptiles, even if more rarely used, can be considered as useful indicators because, at least in the Mediterranean regions, they represent an important portion of the vertebrate fauna inhabiting agricultural lands. In addition, their relatively low dispersal ability makes them sensitive to environmental alteration even at field scale (Paggetti *et al*., 2006; Biaggini *et al*., 2009; Biaggini and Corti, 2015). Among reptiles, the most common species in agricultural lands belong to Lacertids (Biaggini and Corti, 2015).

The effects of mowing on Arthropod conservation have been investigated in numerous studies (Chambers and Samways, 1998; Durbian, 2006; Braschler *et al*., 2009). However, rarely the higher taxa approach has been adopted, despite the advantage of supplying information on a broad number of taxa and giving results not related to species-specific responses (Gaston *et al*., 1995; Cardoso *et al*., 2004; Biaggini *et al*., 2007). On the contrary, literature dealing with the effects of mowing on reptiles is very scarce, above all in set-asides (Johnson *et al*., 2000; Durbian, 2006; Sato *et al*., 2014).

Materials and methods

Monitoring areas

Sampling was performed in three farms, in Northern, Central and Southern Italy: 1) *Azienda Pilota e Dimostrativa 'Vallevecchia'* (Caorle, VE); 2) *Azienda di Monitoraggio CREA-ABP Fagna* (Scarperia, FI); 3) *Azienda Agricola Sperimentale Dimostrativa 'Pantanello'* (Metaponto, MT). In each area three plots were identified characterized by the following managements: i) Factual (F): set-aside mowed in mid July; ii) Counterfactual (CF): unmowed set-aside; iii) Control (Ctrl): intensively managed crop.

APD Vallevecchia is located in an area reclaimed since the Sixties of the Past Century, and now dominated by arable lands. Natural habitats like sand dunes and pinewoods are also present along the coastal belt. Plots F and CF measured 85×173 m, Ctrl measured 116×385 m and was part of a corn field. All plots adjoined with 'minor' landscape elements, like ditches with riparian vegetation (just herbaceous in F and CF, with trees in Ctrl) and hedgerows. Such elements may have a role in influencing the fauna composition and abundance in agricultural lands.

AM CREA-ABP Fagna is located in an area dominated by cultivated lands. Plots were at 250 m asl, and adjoined to a wide belt of riparian vegetation. F and CF measured 42×140 m; Ctrl plot was changed during the project because of a technical problem (it measured about 44×185 m in 2012; 24×110 in 2013).

AASD Pantanello is located in a wide cultivated area, with prevalence of arable lands and orchards. The surrounding habitats characterized by relatively low disturbance levels are ecotones and strips of riparian vegetation interspersed among crops. Plots were particularly small in size, which seemingly affected our results: F and CF measured 30×17 m, Ctrl measured 96×39 m.

Sampling methods

Mowing in the three areas was performed around 15th July 2012. Sampling took place in April-May, the 'pre-mowing period', and in September-October, the 'post-mowing period'.

Arthropod diversity

In each area we put 9 pitfall traps, 3 for each management (F, CF, Ctrl), following the methodology described in Biaggini *et al*. (2007, 2011). Traps were emptied and replaced twice during each sampling period, for a total of 36 samples per area. Arthropods were identified at the taxonomical order level, while for Anellida, Nematoda and Mollusca we indicated just the phylum. For brevity's sake, in the text we refer to all Invertebrates as 'ground-dwelling Arthropods' (which were clearly the prevalent group). Coleoptera were identified at the family level.

Lacertid abundance

In each area and plot we performed linear transects in order to gain data on lizard abundance. Following standard methods for reptile sampling (Urbina-Cardona *et al*., 2006), we walked along linear paths recording species and number of individuals observed within 1 m on both sides of the line.

Data analyses

Arthropod diversity

To asses biodiversity levels we calculated the Shannon-Wiener index (H) on both Arthropod orders (HArtr) and Coleopteran families (HCol). To test the possible effects of mowing on Arthropod diversity we compared HArtr and HCol: i) among F, CF and Ctrl in each area, in the pre-mowing and post-mowing periods; ii) between sampling periods for F, CF and Ctrl, in each area. We used Mann-Whitney's and Kruskal-Wallis' tests for comparisons among two and more variables, respectively. Bonferroni's correction was applied to multiple comparisons. For each trap we also calculated the relative proportions of both Arthropod orders and Coleopteran families, considering the total number of specimens captured in the two sampling periods. Then we compared the similarity patterns among traps performing Non-Metric Multidimensional Scaling (NMDS), using Euclidean distances as dissimilarity measure.

Lacertid abundance

To verify the possible effects of mowing on Lacertids, in each area we compared lizard abundance among F, CF and Ctrl, and among sampling periods for each management. We used Past software (Hammer *et al*., 2001) for all statistical analyses.

Results

Arthropod diversity

During monitoring activity we identified 35 Arthropod orders and 52 Coleopteran families. The comparisons of HArtr among F, CF and Ctrl did not reveal significant differences in both the pre- and the post-mowing periods (Table 1, Figure 1). However, the comparisons of biodiversity levels between sampling periods highlighted that, in the post-mowing period, HArtr in F (mowed set-aside) showed the highest HArtr values observed in each area. In Fagna and Metaponto, where biodiversity increased from spring to autumn, HArtr in F grew more than elsewhere, in a statistically significant measure; in Caorle, where the seasonal trend was decreasing, HArtr grew in F (Table 1; Figure 1).

The analysis of HCol indicated quite similar patterns (but statistically less significant). The comparisons among F, CF and Ctrl did not reveal significant differences in both the pre-mowing and the post-mowing periods (Table 1; Figure 2). The comparison between sampling periods indicated that HCol in F followed the same trends than in CF and Ctrl: increasing in Fagna and Metaponto; but decreasing in Caorle (Figure 2) where, however, biodiversity seemed to decrease less in F than in CF and Ctrl.

NMDS performed on Arthropod orders highlighted a clear distinction of the faunistic composition in the two sampling periods (Figure 3). In the pre-mowing period traps belonging to different managements showed just slight differences. On the contrary, after mowing, in Fagna and Caorle F traps were clearly separated from CF and Ctrl (clustered together); in Metaponto, the analysis distinguished all the three managements and F traps were represented closer to CF than to Ctrl ones.

Table 1. Comparisons among treatments in the pre-mowing and post-mowing periods, and comparisons between the two periods for each treatment of the three variables: Shannon-Wiener index of Arthropod orders (HArtr), Coleopteran families (HCol), and Lacertid abundance.

H	Site	F/CF/Ctrl Pre-mowing	F/CF/Ctrl Post-mowing	F Pre/post	CF Pre/post	Ctrl Pre/post
HArtr	Caorle	H=0.889; P=0.641	H=6.877; P=0.032 *Post-hoc* n.s.	U=9, P=0. 173	U=12, P=0. 379	U=12, P=0. 379
	Fagna	H=5.485; P=0.064	H=4.287; P=0.117	U=0, P=0.008 Post>Pre	U=15, P=0. 689	U=10, P=0. 411
	Metaponto	H=0.433; P=0.805	H=6.538; P=0.038 *Post-hoc* n.s.	U=1, P=0.008 Post>Pre	U=10, P=0. 230	U=17, P=0.936
HCol	Caorle	H=1.912; P=0.384	H=0.737; P=0.692	U=17, P=0.936	U=11, P=0.298	U=5, P=0.083
	Fagna	H=7.942; P=0.019, F<Ctrl, P=0.015	H=2.346; P=0.310	U=0, P=0.008 Post>Pre	U=12, P=0.379	U=8, P=0.235
	Metaponto	H=1.836; P=0.399	H=0.421; P=0.810	U=13, P=0.471	U=18, P=0.936	U=8, P=0.128
Lacertids	Caorle	H=0.162; P=0.598	-	U=33; P=0.556	U=33; P=0.556	-
	Fagna	H=0.162; P=0.598	H=0.595; P=0.522	U=52.5, P=0.890	U=52.5, P=0.890	U=5.429, P=0.040 Post>Pre
	Metaponto	H=1.935; P=0.262	H=0.198; P=0.847	U=81.5, P=0.862	U=84.5, P=0.972	U=87.5, P=0.268

F, factual; C, counterfactual; Ctrl, control.

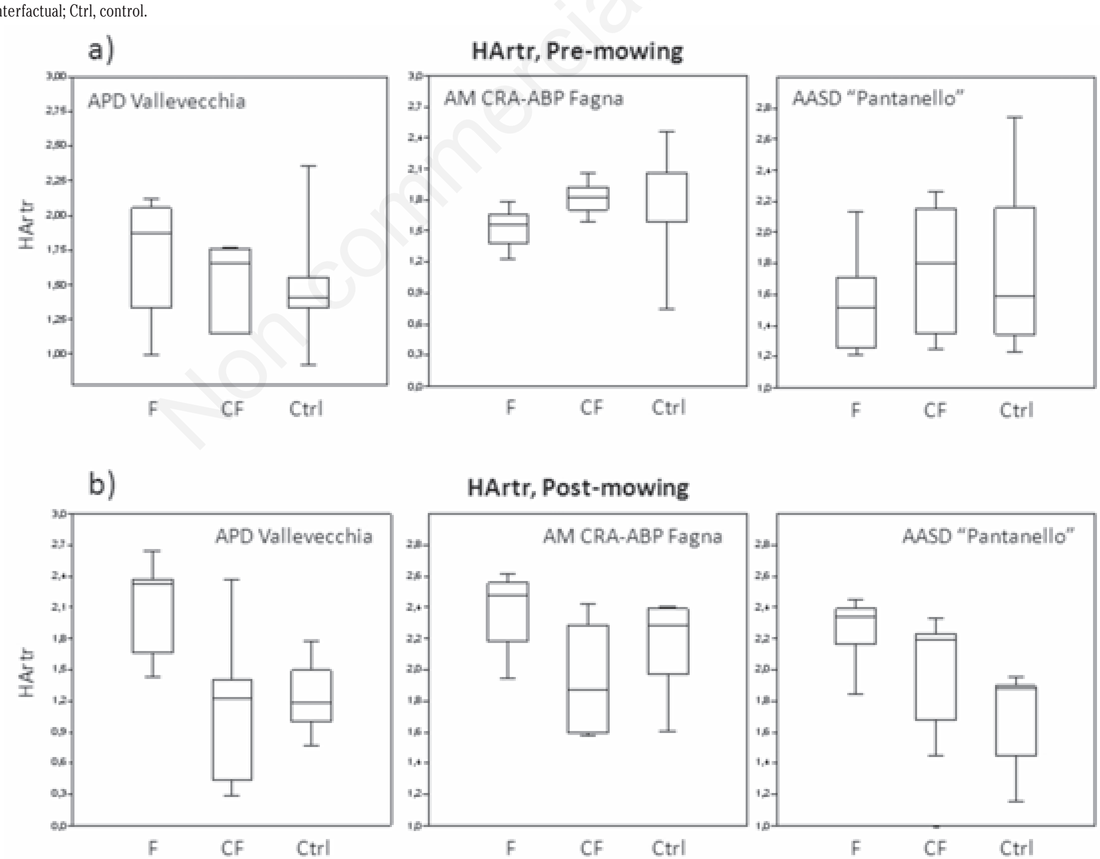

Figure 1. HArtr values in the three treatments (F, factual; CF, counterfactual; Ctrl, control) in the three monitoring areas, in the pre-mowing (a) and post-mowing (b) periods. Boxplots represent median, 25-75% quartiles and extreme values.

In the three areas the Arthropod composition in the post-mowing period was more balanced in F than in CF and Ctrl, considering the relative proportions of the different orders (Table 2): i) in Caorle, passing from spring to autumn, the proportion of Coleoptera broke down in CF and Ctrl (where Collembola strongly dominated in September-October) while it remained relatively high in F; in Fagna, after mowing, F was characterized by the presence of high percentages of Diptera, Collembola and Coleoptera while in CF (the unmowed set-aside) prevailed just Diptera; also in Metaponto, after mowing, F was characterized by more orders showing relatively high percentages.

NMDS performed on Coleoptera families highlighted a seasonal pattern just for Fagna and Metaponto (Figure 3). In Fagna, in the pre-mowing period, Ctrl traps appeared clearly distinct from F and CF ones (due to high percentages of Colididae and Nitidulidae, Table 3), while after mowing a more homogeneous fauna composition was observed (but the Ctrl plot was changed in the course of monitoring activity). In Metaponto, the same analysis showed patterns consistent with those obtained for the Arthropod orders: a clear distinction between seasons; general homogeneity in the faunistic composition in the pre-mowing period; distinction of Ctrl traps in the post-mowing period (due to the high percentage of Anthicidae). In Caorle, the only traps clustered apart by NMDS were Ctrl traps in the pre-mowing period (due to a lower presence of Carabidae, and to a higher presence of Anthicidae, Aphodidae and Elateridae) (Table 3). NMDS stress values are shown in the graphs (Figure 3).

Lacertid abundance

During transecting we observed two species of Lacertid lizards: *Podarcis siculus* in Caorle and Metaponto, *P. siculus* and *P. muralis* in Fagna. In the three areas we did not find significant differences in lizard abundance among managements (F, CF, Ctrl) in the same sampling period, and between periods for the same management (Table 1; Figure 4) (the significant difference observed for Ctrl plot at Fagna might depend on plot replacement). F and CF showed similar values of lizard abundance in each of the three areas.

Discussion and conclusions

Data gained in the monitoring project MO.NA.CO. indicated, as a whole, that a mild management of set-asides, consisting in mowing once a year (mid July in the examined areas), may enhance faunal diversity, above all Arthropod diversity.

The higher taxa approach (using the taxonomical levels order and family) turned out to be an effective tool to analyze Arthropod fauna, highlighting variations of fauna diversity and composition in relation to different seasons and managements. Indeed, neighboring plots with different managements were clearly distinguishable in most of the surveyed cases, which also stressed the key role of land management in influencing fauna composition (Di Giulio *et al*., 2001). The reliability of higher taxa approach, at least in investigations dealing with agro-environments, has been already demonstrated (Biaggini *et al*., 2007; Cotes *et al*., 2011), as well as its advantage in retaining a certain amount of information on a large number of taxa (Cardoso *et al*., 2004). In particular, the analyses made at the order taxonomical level, that gave the strongest contrasts in this monitoring project, allow to gain results in a relatively quicker and simpler way in comparison to the species level identification (Biaggini *et al*., 2007). All these aspects make this approach particularly suitable for applicative studies, like the evaluation of agro-environmental measures.

Analyzing Arthropod orders, we observed that diversity levels in the post-mowing period were, on average, higher in the set-asides mowed at mid July (factual plots) than in the unmanaged set-asides and in the

Table 2. Percentages of Arthropod orders (>3%).

	Araneae	Blattodea	Coleoptera	Collembola	Diptera	Hemiptera	Hym. Formicidae	Isopoda	Lepidoptera	Orthoptera	Others (<3%)	Tot. orders
APD Vallevecchia												
Pre												
F	13.11		55.39		7.19		14.38	7.4			2.54	8
CF	25.93		56.04				7.91	4.4			5.71	8
Ctrl	6.8		54.37	11.65	17.48				3.88		5.83	8
Post												
F			32.84	42.37	9.31	5.67	3.57				6.23	15
CF			4.98	89.7	3.24						2.09	10
Ctrl			10.24	78.97	7.28						3.51	14
CREA-ABP Fagna												
Pre												
F	4.79		51.45				5.54			35.92	2.3	13
CF	5.33		47.47	6.03			10.05			27.71	3.41	13
Ctrl			22.09	8.52	44.84		13.68				10.87	13
Post												
F	7.57		15.91	26.29	36.37	3.78					10.09	15
CF	4.97		26.41	9.73	47.92					3.27	7.69	17
Ctrl			22.09	8.52		44.84	13.68				10.87	13
AASD Pantanello												
Pre												
F	18.38		54.05		17.02						10.54	13
CF	10.88		47.35	12.06	21.76						7.94	11
Ctrl	6.71		40.55	8.84	32.93						10.98	13
Post												
F	4.56	4.56	39.91	33.7	5.33		4.89				7.04	21
CF	7.58		41.49	36.66	5.72						8.55	19
Ctrl		28.15	19.43	46.05							6.37	16

F, factual; C, counterfactual; Ctrl, control.

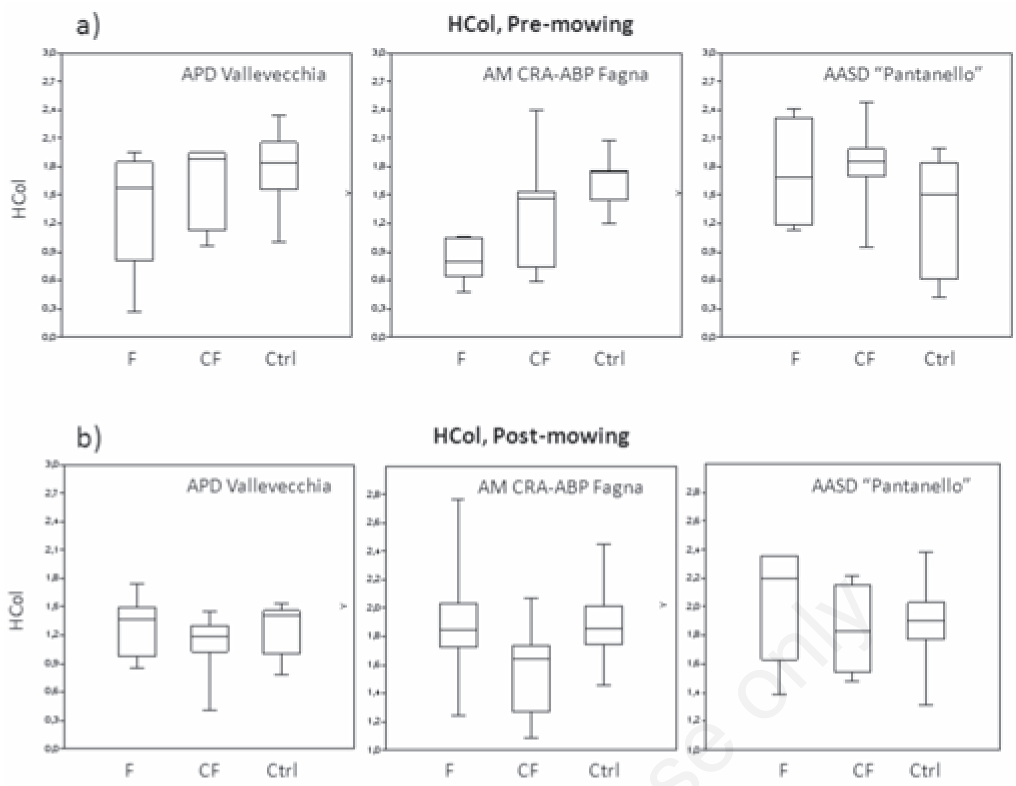

Figure 2. HCol values in the three treatments (F, factual; CF, counterfactual; Ctrl, control) in the three monitoring areas, in the pre-mowing (a) and post-mowing (b) periods. Boxplots represent median, 25-75% quartiles and extreme values.

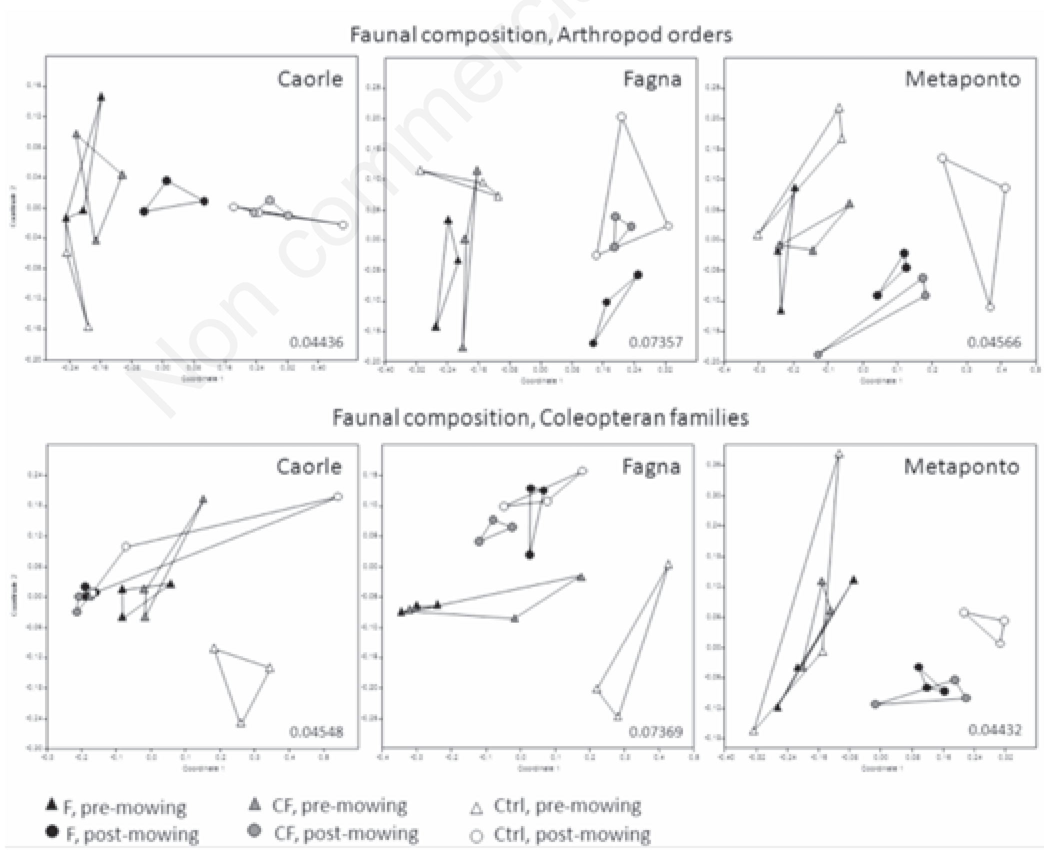

Figure 3. Non-metric Multidimensional Scaling performed on the frequencies of Arthropod orders and Coleopteran families in F, CF, Ctrl, in the three monitoring areas (bottom right: stress value of the analysis).

arable lands. In addition, in the post-mowing period, with respect to spring, biodiversity grew more in the factual plots than elsewhere, irrespective of the monitoring area and of the seasonal variation trends. Such results can be reasonably interpreted as a consequence of mowing. Analogous considerations arose from the analysis of Arthropod fauna composition. In two of the three monitored areas (Caorle and Fagna), in the post-mowing period, the unmanaged set-asides hosted an Arthropod fauna very similar to the one characterizing crops, the land uses with the lowest floristic diversity and the highest disturbance. On the contrary, set-asides that were managed following Standard 4.2 supported a more balanced faunal composition in terms of taxa proportions. Further monitoring activities performed in the context of MO.NA.CO. project, using the same indicators, showed a positive effect of mowing on the diversity of ground-dwelling Arthropods in olive orchards, too (Corti *et al*., 2015). Similarly, other studies demonstrated the beneficial role of mowing for the species richness of some Arthropod taxa, at field and landscape levels (Chambers and Samways, 1998; Braschler *et al*., 2009; Marini *et al*., 2009).

However, it is very difficult to give a univocal interpretation of the relationship between mowing and fauna conservation, also considering the available literature. The studies dealing with such topic show a high variability of results depending, for example, on the group of organisms chosen as indicator, on the timing of the managing practices, and on the length of the period covered by the study. Certainly, mowing has immediate negative effects on Arthropods, causing translocation and killing of eggs, larvae and adults (Morris, 2000; Gardiner and Hill, 2006; Marini *et al*., 2008; Humbert *et al*., 2009). Such effects, in a longer time lapse, can lead to a significant decrease in the populations of certain species (Völkl *et al*., 1993; Johst *et al*., 2006). Moreover, the repeated cut of vegetation can bring indirect effects related to meadow habitat alteration (Curry, 1994; Gerstmeier and Lang, 1996; Painter, 1999). Mowing, indeed, causes changes in the floristic composition of meadows which may imply, in turn, variations in the resource availability, microclimatic conditions, and presence of suitable substrates for Arthropod eggs and larval phases (Curry, 1994; Painter, 1999). However, in general, it is commonly accepted that mowed meadows can support higher levels of species richness and diversity of both flora and Arthropod fauna, with respect to unmanaged meadows (Chambers and Samways, 1998; Collins *et al*., 1998; Stampfli and Zeiter, 1999; Huhta *et al*., 2001; Williams *et al*., 2007; Braschler *et al*., 2009; Marini *et al*., 2009; Yang *et al*., 2012; Valkó *et al*., 2012).

Vertebrate fauna, as well (in particular herpetofauna, grassland birds, micro-mammals) suffers from disturbance, wounding and killing by mechanical treatments (Johnson *et al*., 2000; Durbian, 2006). These effects are particularly dangerous in the reproductive season. It is ascertained that mowing can destroy nests and eggs of grassland birds, kill nestling and adults, and alter the resource availability, as well (Bollinger *et al*., 1990; Frawley and Best, 1991). According to the few studies available on reptiles (Johnson *et al*., 2000; Durbian, 2006), mechanical mowing causes high mortality rates among these vertebrates, and it can indirectly influence species distribution as a consequence of altered thermal conditions and reduced refuge availability (Sato *et al*., 2014). In our study we monitored the plots two months after mowing, when direct impacts of mechanical practices (which were not among our aims) could not be observed. Apart from such direct impact, which probably occurred in the monitored areas, too, data gained during MO.NA.CO. project seemed to indicate that mowing does not influence lizards abundance and the observed variation patterns were probably ascribable to seasonal trends rather than to managing regimes. However, a long term monitoring program could be useful to better evaluate the effectiveness of the Standard 4.2c in relation to lizard conservation. Indeed, managing of grass vegetation can favour the presence of reptiles by preventing the creation of habitats with a too thick vegetation (Edgar *et al*., 2010) but, at the same time, mowing regimes which are planned without considering the ecological requirements of these vertebrates, can sometimes lead to the creation of unsuitable habitats (Sato *et al*., 2014). In general, independently from the kind of land use management, the diversity and abundance of vertebrate fauna in agricultural lands is surely deeply influenced by the surrounding habitats. In particular, even minor landscape elements, such as ditch banks, field margins, and small woodlots can play a fundamental role in shaping the presence of fauna in agro-environments (Biaggini and Corti, 2015). Such influence was surely present in the monitored areas, too.

Standard 4.2 establishes that mowing (or analogous practices, EC 73/2009) must be performed at least once a year, avoiding the period from 15th March to 15th August (EC 73/2009) in the areas included in the *Natura 2000* network (2009/147/EC and 92/43/EEC). In all the other areas mowing must be avoided for 120 consecutive days included in the above mentioned period, whereas some waivers can be applied (*e.g.* in order to prevent weed dispersal). However, in order to preserve bio-

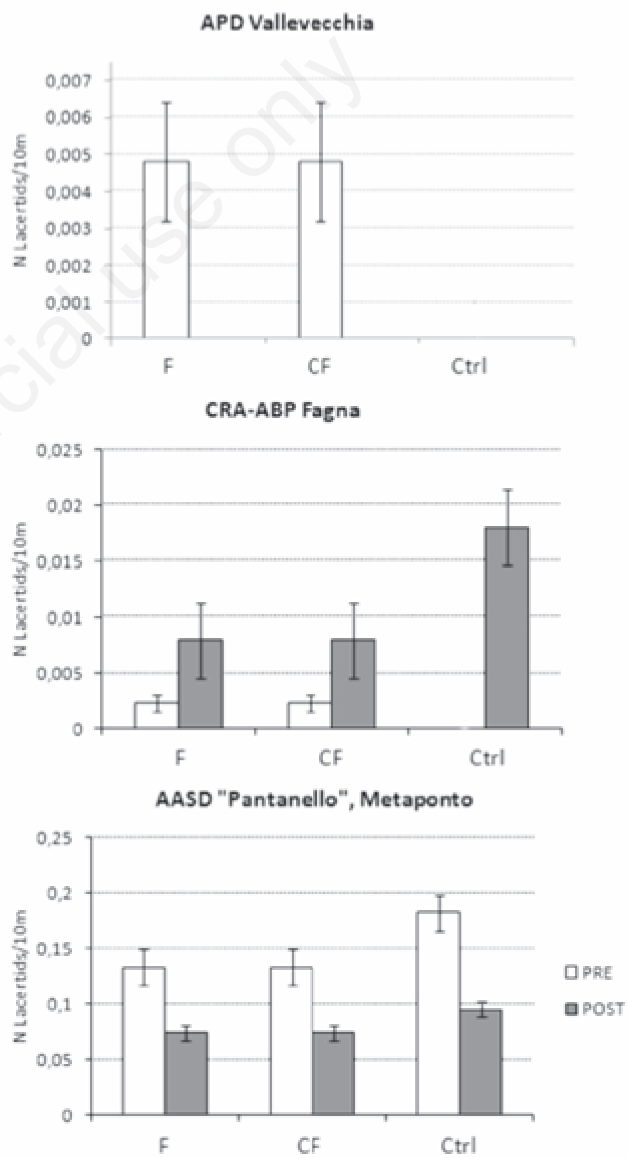

Figure 4. Lacertid densities in the three monitoring areas. in pre-mowing (April-May) and post-mowing (September-October) periods.

Table 3. Percentages of Coleopteran families (>2%).

	Anthicidae	Aphodidae	Carabidae	Cetoniidae	Chrysomelidae	Clambidae	Colidiidae	Cryptophagidae	Curculionidae	Dermestidae	Elateridae	Latridiidae	Leiodidae	Nitidulidae	Scidmenidae	Silphidae	Staphylinidae	Tot. Families
APD Vallevecchia																		
Pre																		
F			62.60													14.50	16.79	7
CF			46.27													21.96	16.47	7
Ctrl	35.71	12.5	12.5	3.57							19.64						12.5	8
Post																		
F	2.13		74.63											3.84			14.71	8
CF			77.21											6.25		4.04	9.19	8
Ctrl			67.58											9.52			19.41	9
CREA-ABP Fagna																		
Pre																		
F	2.378		88.53														3. 50	14
CF	5.15		74.46				2.58			4.72							9.87	12
Ctrl	2.80		30.07				27.27	4.55		3. 50				11.89			19.23	9
Post																		
F	8.54		52.44											6.1			18.29	15
CF	5.90		67.98														19.38	11
Ctrl	18.78		49.75		2.03				2.03					4.57			19.29	10
AASD Pantanello																		
Pre																		
F			59.5						3.5					2.5			16	10
CF			50.93						5.59					2.48			25.47	13
Ctrl			57.89										2.26	4.51			27.82	9
Post																		
F	3.86		36.09		11.57									36.91	2.75		3.03	15
CF			42.5		3.08	2.31								37.12	4.04		6.15	17
Ctrl	25.552		14.60									2.92		45.01	6.33		2.68	12

F, factual; C, counterfactual; Ctrl, control.

diversity in set-asides, mowing only once a year would be recommended because repeated cuts per year can lead to a significant decrease of biodiversity (Gardiner and Hill, 2006; Johst *et al*., 2006; Marini *et al*., 2008; Braschler *et al*., 2009; Valkó *et al*., 2012). Besides, the period in which mowing is not allowed (15th March-15th August) should be extended, without waivers, also to those areas which are not included in the *Natura 2000* network. A further mitigation measure against the negative effects of mowing could consist in planning a temporal and spatial rotation of the management practices. Assuring the presence of set asides (or even just grass strips) characterized by different management timing, indeed, can supply refuges and alternative sites to a large variety of organisms, among which Arthropods (Painter, 1999; Balmer and Erhardt, 2000; Braschler *et al*., 2009; Humbert *et al*., 2009; Noordijk *et al*., 2010), Vertebrates (Edgar *et al*., 2010) and plants (Köhler *et al*., 2005; Bissels *et al*., 2006; Valkó *et al*., 2012).

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