Annex I_PNGP

1 The test sites

1.1 Wetland ecosystems (Dres)

It is a mosaic landscape composed by a humid site that represents one of the largest humid systems of the PNGP and a mix of secondary grasslands and wooded pastures. This surface represents a portion of a bigger site, characterised by the reduction of meadows due to the strong recolonisation of shrubs and trees, following the abandonment of traditional grazing in the 90s. Both are characterised by different habitats listed in the Habitats Directive 92/43/CEE (i.e., HD code 7140 "Transition mires and quaking bogs"; 7110 "Active raised bogs"; 3220 "Alpine rivers and the herbaceous vegetation along their banks"; 6520 "Mountain hay meadows"; 9420 "Alpine Larix decidua and/or Pinus cembra forests"; 4060 "Alpine and Boreal heaths").
The humid site was inappropriately managed until the 90s (uncontrolled grazing, drainage) and the purchase will guarantee its recovery and its protection against further inappropriate management. Both sites are endangered by uncontrolled sheep grazing, which is carried out near the Park's boundary (ca. 1000 sheep). Sheep periodically violate the Park territory, damaging the vegetation, in particular the humid site. The land purchase and the cooperation with the new herder have offered an important instrument to protect from uncontrolled sheep grazing. In this area, the PNGP, thanks to the cooperation with a herder, which is developing a sustainable cattle grazing since 2015, will improve the ecological functionality of the site, reducing the shrubs recolonisation.
During the project we performed two different strategies with the collaboration of herder:

- *grazing exclusion of the humid site* (after the land purchasing the exclusion has become permanent)
- *use historical grazing areas at low altitude* with a system of water management

1.2 Alpine pastures (Gran Pra)

This study site is located in a subalpine-alpine pasture (ca. 2000 m a.s.l.; E 7°19’; N 45°32’) in the Gran Paradiso National Park. The area is characterised by grasslands with different herbaceous associations, moulded for a long time by grazing activities. Some of these coenosis are included in Annex I of the Habitats Directive (HD, 92/43/CEE; i.e. HD code 6110, 6150, 6230*), the most widespread herbaceous coenosis are dominated by *Poa violacea, Nardus stricta, Trifolium alpinum, Carex sempervirens* (39% of the area) and *Festuca scabriculmis* subsp. *luedii and Carex curvula* (22%), as a consequence of years of human exploitation. Traces of both abandonment and over-exploitation can be seen in and around the pasture. Abandonment is visible in the vegetation, particularly in the more peripheral areas far from the main *alpages*. This is mostly oligotrophic and species such as *Festuca scabriculmis* subsp. *luedii* have expanded greatly in terms of density and area covered. On the opposite, in many central portions of the pasture, there are evident traces of overgrazing (i.e. nitrophilous associations of *Urtica dioica* and *Chenopodium bonus-henricus* and areas locally dominated by *Veratrum album*, a toxic unpalatable species). During the project, the herder was involved in two main activities to improve pasture quality and evaluate its long term resilience to climate change and its influence on biodiversity conservation: i) *application of good practices*, mainly determined by rotational grazing, accepted and adopted by the herder; ii) <u>*use historical grazing areas at low altitude*</u> with a system of water management and distribution.

1.3 Subalpine pastures (Noaschetta)

The area is characterized by a high degree of isolation and marginality. It's located in a montane belt on acid metamorphic rocks (gneiss). In the period between the two wars, the terraced areas at lower altitudes were reforested with conifers to avoid the effects of erosion, in response to the abandonment of agro-pastoral activities. Unmanaged extensive grazing activity was carried out until 2016, leading to areas characterized by excessive livestock overload in a context of general abandonment and the open areas were colonized by trees and shrubs. Vegetation encroachment occurred fast and species like *Betula pendula*, *Rosa canina* aggr., and *Genista* sp. surround the area. The most representative habitat (sensu HB, 92/43/CEE) are 6150 and 6230*, dominated by species such as *Festuca scabriculmis* subsp. *luedii* (Festucion variae), *Agrostis schraderana*, *Calamagrostis villosa* (Agrostion schraderianae), *Nardus stricta* (Nardion strictae) and *Brachypodium caespitosum*. In wettest areas, transitions are occurring with locally abundant *Deschampsia caespitosa* while where rocks and blocks are mixed with pastures there are important clumps of ferns (mainly *Athyrium filix-femina* and *Dryopteris affinis*).
During the project we performed three different strategies:

- <u>*The use of a service flock*</u> to maintain open areas
- <u>*Use historical grazing areas at low altitude*</u> with a system of water management
- The comparison in terms of biodiversity of grazed and ungrazed areas

2. The biodiversity monitoring

In three of the test sites we also performed biodiversity monitoring in order to evaluate effects of adaptation strategies tested on animals and vegetation.

2.1. Wetland ecosystems

Since the beginning of the LIFE project, we have monitored different components of animal biodiversity to characterise the heterogeneous landscape of the «Dres area» as accurately as possible. Moreover, many monitoring activities are a prosecution of already existing monitoring projects, previously carried out inside GPNP thanks to other projects, completed by the beginning of the LIFE itself, or thanks to internal resources.

To characterise the wetland ecosystems, we monitored <u>***water beetles***</u> (*Coleoptera*, *Dytiscidae*, *Hydrophilidae*, *Helophoridae*) during 2018 and 2019, prosecuting a project started in 2014. We characterised the community composition of the ponds, identifying 9 species, and we carried out a mark-release-recapture study on the 3 most abundant species (*Agabus congener*, *Agabus guttatus*, *Agabus bipustulatus*). This MRR project allowed us to identify the most important ponds in this wetland system, which should be absolutely maintained through time and preserved from cattle grazing (Fig. 1).

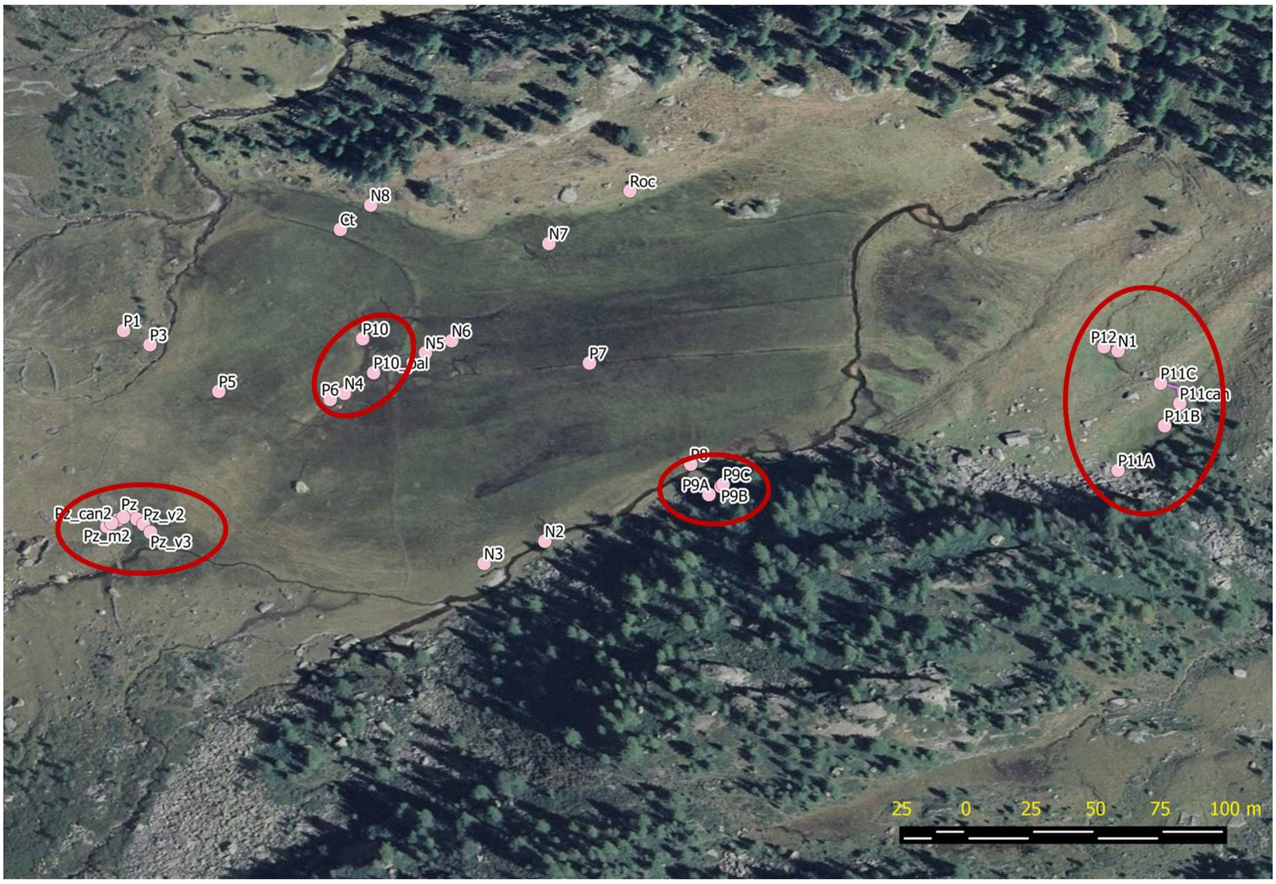


Fig. 1. Cartography of the Dres humid area. Pink dots represent small ponds, in which water beetles were monitored from 2014 to 2019. Red circles represent the groups of ponds, hosting the majority of water beetle populations, important for their long-term conservation.

Another important taxon, which should be monitored in humid areas, is represented by dragonflies (*Odonata*). During the LIFE project, we didn't carry out standardised monitoring of dragonflies, because we already know the species breeding in the area (i.e., *Aeshna juncea* and *Somatochlora alpestris*) and the mainly used ponds.

To analyse the impact of grazing activities on the grassland surrounding the wetland and in the woodland clearings, we monitored pollinators, in particular butterflies (*Lepidoptera Papilionoidea* and *Hesperioidea*), bumblebees (*Hymenoptera Apidae*, genus *Bombus*) and hoverflies (*Diptera Syrphidae*). For each taxon, we carried out 3 linear transects with monthly repetition (July-September).

Concerning ***butterflies***, we monitored them each year since 2019. We identified **50 species**, which characterised the monitored areas, some of them being hygrophilous species, while others more linked to xerophilous/thermophilous habitats or even to ecotonal environments, underlining the importance of maintaining landscape heterogeneity. Some of the observed species are of particular interest because they are not widespread in the rest of the park (e.g., *Colias palaeno*, *Albulina optilete*, *Carterocephalus palaemon*). We observed a slight decrease through years in both species richness and abundance (2021-2022 vs 2018-2019), probably related to water scarcity, which has increased over the past two years. Indeed, water scarcity, as well known, can lead to an early end of the vegetative season, with pastures already dry at the beginning of September and consequently less availability of flowers.

Concerning ***bumblebees***, we monitored them from 2020 to 2022. We identified **19 species**, representing a high proportion of the bumblebees currently known for the GPNP. In particular, among them, we also found *Bombus mendax*, a species that lives in small underground colonies restricted to high alpine and subalpine areas and that due to its restricted distribution (Cantabrian Mountains, Pyrenees, Alps) is considered to be Near Threatened in the IUCN Red List of European Bees.

Concerning ***hoverflies***, we monitored them during 2021 and 2022. We identified **35 species**, among which some can be considered of particular conservation interest. As an example, we observed *Didea alneti*, quite a rare species, with arboreal predator larvae. Moreover, we identified a group of species, linked to wet habitats: *Neoascia tenur*, a species strictly associated to humid fen and moorland; *Chrysotoxum fasciatum*, a typical species of woodland clearings in the vicinity of humid or poor drained ground; *Sericomya silentis*, a species quiet rare in Italy, localised in the Alps and in the Appennines, which lives at the edge between forest and wetland and breeds in small pools. Interestingly, a huge difference has been found between 2021 and 2022, with a strong reduction both in abundance and in species richness in 2022, another time highly probably related to drought.

Before and in the years of project, it was carried out also the annual monitoring activities of the ***black grouse*** (*Lyrurus tetrix*) performed by the park wardens.

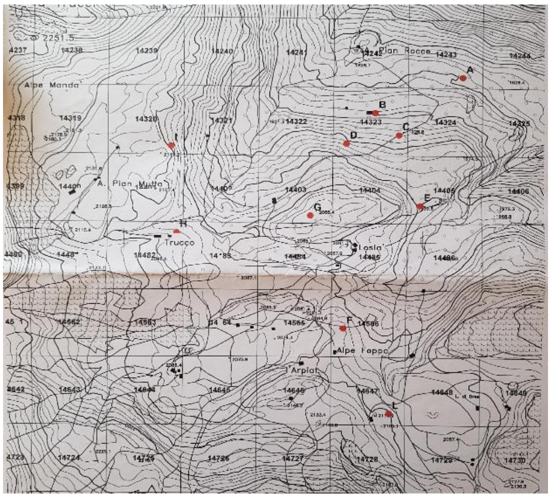


Fig. 2. Map of the black grouse census stations

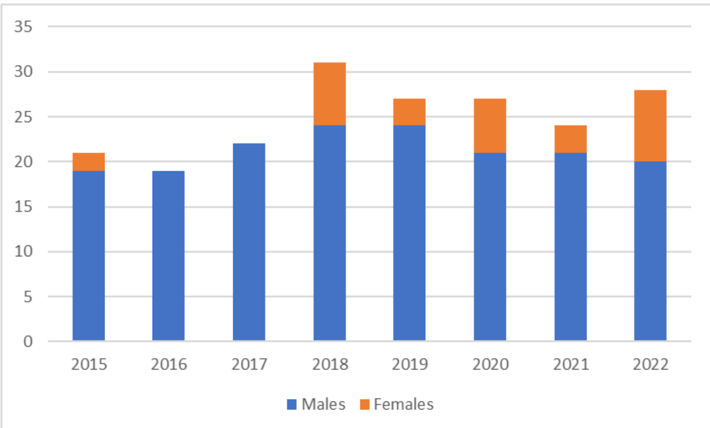


Fig. 3 Black grouse population dynamic.

Data on black grouse population show a moderate increase after the beginning of the project even if only long term data can be useful for population dynamic analysis. Nevertheless the maintenance of open areas and of the environmental mosaic thanks to the grazing activities are fundamental to ensure the black grouse population viability.

To sum up, our monitoring activities allowed us to:

- underline the important conservation concern of this area, characterised by a mosaic of shrubs, woodlands and ponds;
- identify the most important sub-areas, which should be preserved even from light grazing;
- create an important baseline for standardised monitoring against which to identify future changes;
- highlight the strong vulnerability of the area to drought and water scarcity.

2.2 Alpine pastures

To evaluate the long-term effects of pastoral activities on biodiversity and in particular the effects of improved management, due to the cooperation between the herder and the Park, we monitored invertebrates in four plots, characterised by different grazing pressure. We focused our monitoring on pollinators, in particular, butterflies (*Lepidoptera Papilionoidea* and *Hesperioidea*), bumblebees (*Hymenoptera Apidae*, genus *Bombus*) and hoverflies (*Diptera Syrphidae*). We monitored them through the application of a linear transect (length 200 m, from the end of June until the beginning of September, every 15 days).

We monitored ***butterflies*** yearly since 2019 and we found a total of **67 species**, including two species listed in the Annexes of the Habitat Directive, *Parnassius apollo* and *Maculinea arion*. In particular, *Parnassius apollo* is a regular and abundant presence in the study site, showing how well-managed alpine pasture could be effective in supporting butterfly populations, also for vulnerable and demanding species. As previously stated, each transect represents a different level of grazing pressure: "low-intensity" grazing (only marginally grazed), "medium-intensity" (two levels; one characterised by earlier grazing, in July and another, with later grazing, in August), "high-intensity" (with a constant passage of animals returning from grazing areas to the mountain pastures). Our data show clear differences in species richness and abundance of butterflies among these areas. The "high-intensity" area is characterised by the lowest species richness and abundance, even if not really few species are present also there (a total of 31 species cumulated through 4 years of monitoring). The other monitored areas ("low-intensity" and "medium-intensity"), characterised by lower pressure, host richer and better-structured butterfly communities (more than 50 species per transect), giving comparable results. In any case, the best solution seems to be "medium-intensity" grazing, during the second half of August, both in terms of abundance and species richness.

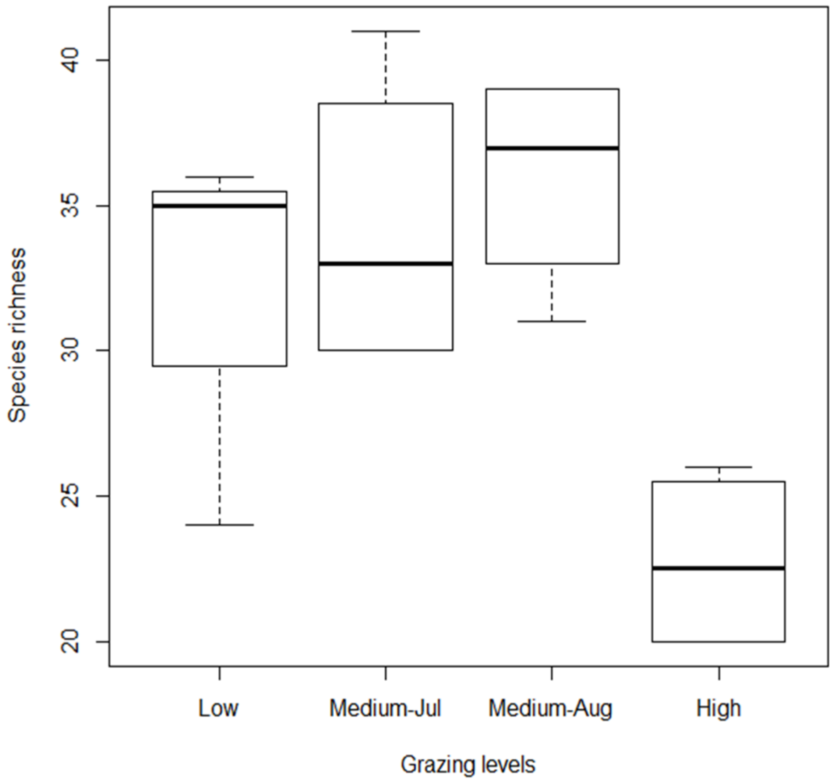


Fig. 4 Species richness per grazing level. Jul = July; Aug = August.

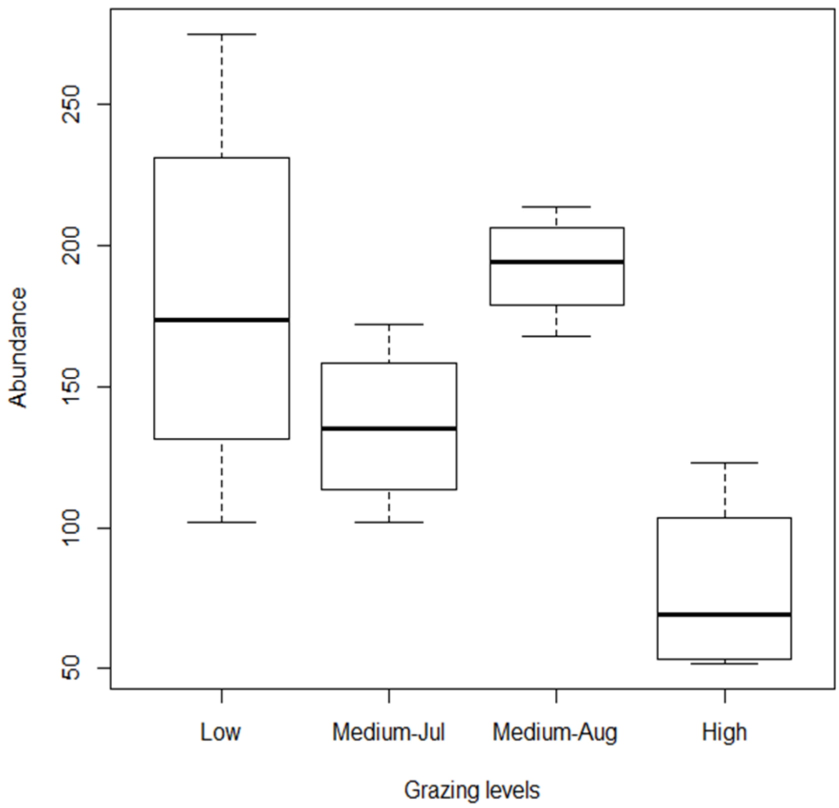
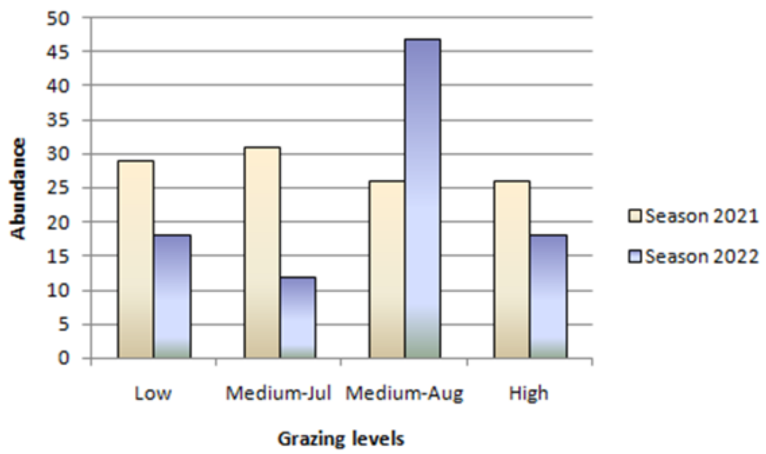


Fig. 5 Number of individuals per grazing level. Jul = July; Aug = August.

These results give important insight into the optimal grazing management for butterflies, even if what we observed is strictly related to the particular habitat and topography of our study site and to generalise the results more independent observations are needed.

We monitored ***hoverflies*** in 2021 and 2022, founding a total of **37 species**. We found results similar to butterflies, but not completely overlapping. Cumulating data over the 2 years, quite similar to butterflies, we observed higher species richness and abundance in the plot grazed with medium intensity and starting from August ("low grazing" = 17 species, 47 individuals; "medium grazing – July" = 17 species, 43 individuals; "medium grazing – August" = 21 species, 73 individuals; "high grazing" = 13 species, 44 individuals). But in particular, we observed marked differences among years and observing each year independently, the situation is far less clear (Fig. 9). Abundances are quite similar among grazing levels in 2021, while in 2022 the plot characterised by "medium-grazing" in August has the highest abundance, but mainly determined by an increase in 3 single species (*Eristalis tenax*, *Spaherophoria scripta*, *Scaeva pyrastri*). Also concerning species richness, differences in grazing levels emerged especially in 2022, while in 2021 the four grazing levels appear as more homogeneous.



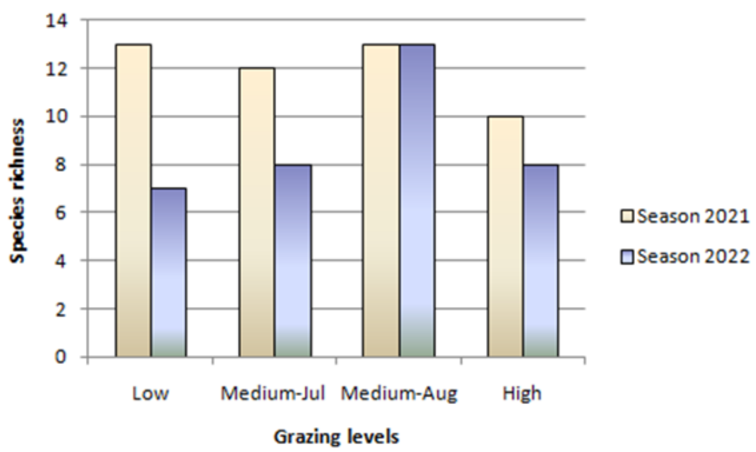


Fig. 6.a and **6.b** Species richness and abundance in the hoverflies population within different grazing intensity. Jul = July; Aug = August.

Hoverflies appear as characterised by yearly fluctuations in both abundance and species richness, so the exact relationship between them and grazing levels should be deepened to have a clearer picture of the real situation.

We also monitored ***bumblebees***, in 2020, 2021 and 2022. We found a total of **18 species** and 423 specimens over the three years, like in the following table.

Species	2020	2021	2022	Total
B. bohemicus			**1**	**1**
B. hortorum		**6**		**6**
B. humilis	**2**	**1**	**3**	**6**
B. hypnorum		**4**		**4**
B. lapidarius		**16**	**5**	**21**
B. lucorum	**23**	**21**	**32**	**76**
B. mesomelas	**9**	**26**	**8**	**43**
B. monticola		**1**		**1**
B. mucidus	**4**	**1**	**1**	**6**
B. pascuorum	**2**	**9**	**3**	**14**
B. pratorum	**2**	**4**	**2**	**8**
B. ruderarius	**4**	**43**	**25**	**72**
B. rupestris		**2**		**2**
B. sichelii	**1**	**5**	**6**	**12**
B. soroeensis	**19**	**71**	**44**	**134**
B. sylvarum	**1**			**1**
B. terrestris	**4**		**1**	**5**
B. wurflenii	**7**	**3**	**1**	**11**
Total	**78**	**213**	**132**	**423**

Like with butterflies and hoverflies we checked the bumblebee abundance in relation to the grazing levels: High, medium, and low. The medium level is divided into two: one characterized by earlier grazing, in July and another, with later grazing, in August.

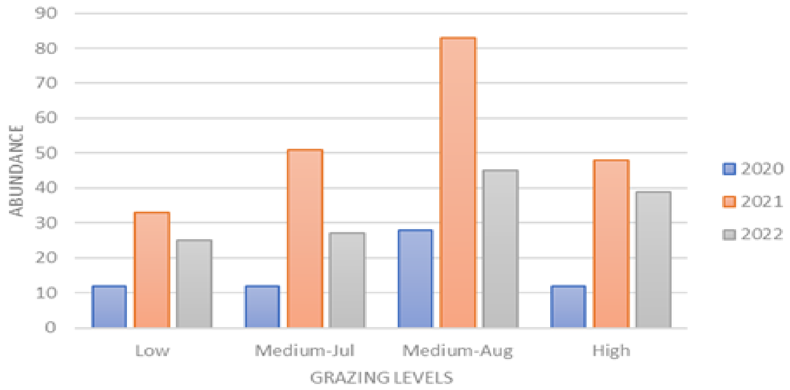
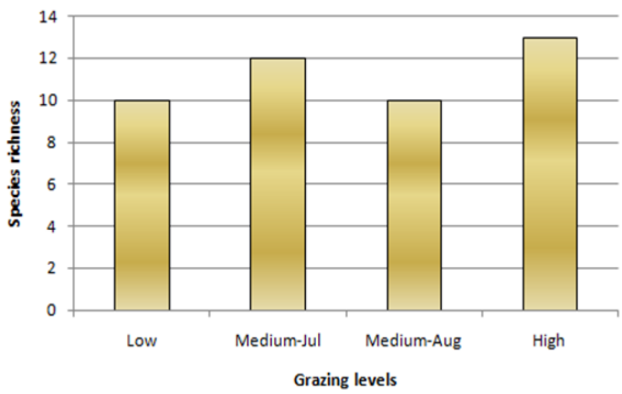


Fig. 7. Abundance in the bumblebee population within different grazing intensity. Jul = July; Aug = August.

The abundance varies a lot through the years, but it still has a similar pattern: we observed that there is a preference for bumblebees for the late medium grazing level, which they have in common with butterflies and hoverflies and on the contrary there are less specimens found in the low level grazing.

Concerning ***Orhoptera*** (grasshoppers and crickets), we monitored them in 2020 and 2021 and we found **15 species**. Orthoptera give a different pattern, with similar species richness among grazing levels and the highest values in the most grazed area. The species present in our alpine pasture appear as not particularly sensitive to grazing intensity: indeed they are not strictly related to specific plant species or flowers but to vegetation associations and could be advantaged by the microhabitat heterogeneity created by grazing. As for the other taxa, the highest abundance has been found in the plot grazed in August, but, once again, differences are not marked, in particular with the most grazed plot. In any case, observing these results, we must consider that also our highly grazed plot is surrounded by low-grazed and natural alpine pasture, which could serve as a reservoir for the observed species.



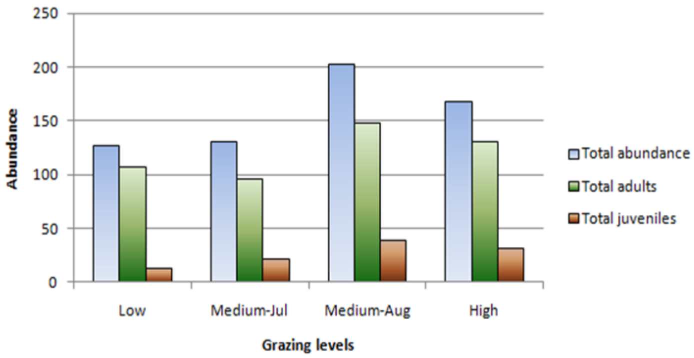


Fig. 8.a and **8.b** Species richness and abundance in the grasshopper population within different grazing intensity. Jul = July; Aug = August.

2.3 Subalpine pastures

Biodiversity was monitored in each patch of the Noaschetta area both at community level and to consider difference in grazed and ungrazed areas

Grasshopper and crickets were monitored with the ring counts method, using a plastic cylinder 50 cm in height, with a 150 cm diameter (about 0.18 m^2). We placed the cylinder on the ground 10 times, alternating random and opportunistic attempts, both in the menaged and in the control areas. *Orthoptera* were monitored every 15 days, from the end of July to mid September (2018-2022). We found **24 species** throughout the sampling period. Here are some results from 2022. There is no significant difference in both the total abundance (Wilcoxon test, p=0.89) and the species richness (Wilcoxon test, p=0.67) between managed plots and the control ones. However, the data might suggest that the ungrazed patches could be used as shelters while the grazed portions of the studied areas host more species probably because the grazing enhances the vegetation structure variability.

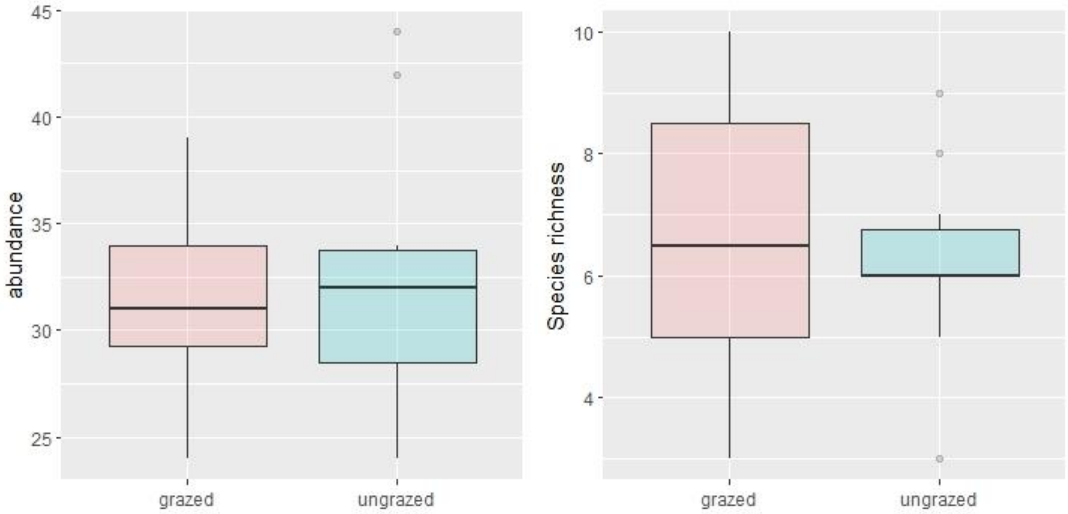


Fig. 9.a and **9.b.** Total abundance and species richness in grazed and ungrazed areas for grasshoppers and crickets

Concerning ***hoverflies***, two methods were used to monitor them: a linear transect (200 m) to get an idea of the hoverflies community and two opportunistic transects per selected area, one grazed and one ungrazed (lasting 10 minutes each) to investigate how adults use these patches. Hoverflies were monitored every 15 days for the opportunistic transects and once a month for the linear transect, from the end of June to the beginning of September, in 2021 and 2022. We found **69 species** (result based on the total number of species found in 2021 plus the 80% of 2022). Although the list of species found is limited, some of them are interesting: three species are considered Near Threatened in the European Red List of Hoverflies (*Spazigaster ambulans, Sphegina cornifera, Sphaerophoria fatarum*) and one species is considered Endangered (*Cheilosia pedemontana*).

Here are some results from 2021. Despite the high variability between areas, the abundance of hoverflies in the ungrazed patches seems to be higher. These results might suggest that the adults prefer the ungrazed area, probably because the donkeys reduce the availability of nectariferous plants, an important food resource for adults.

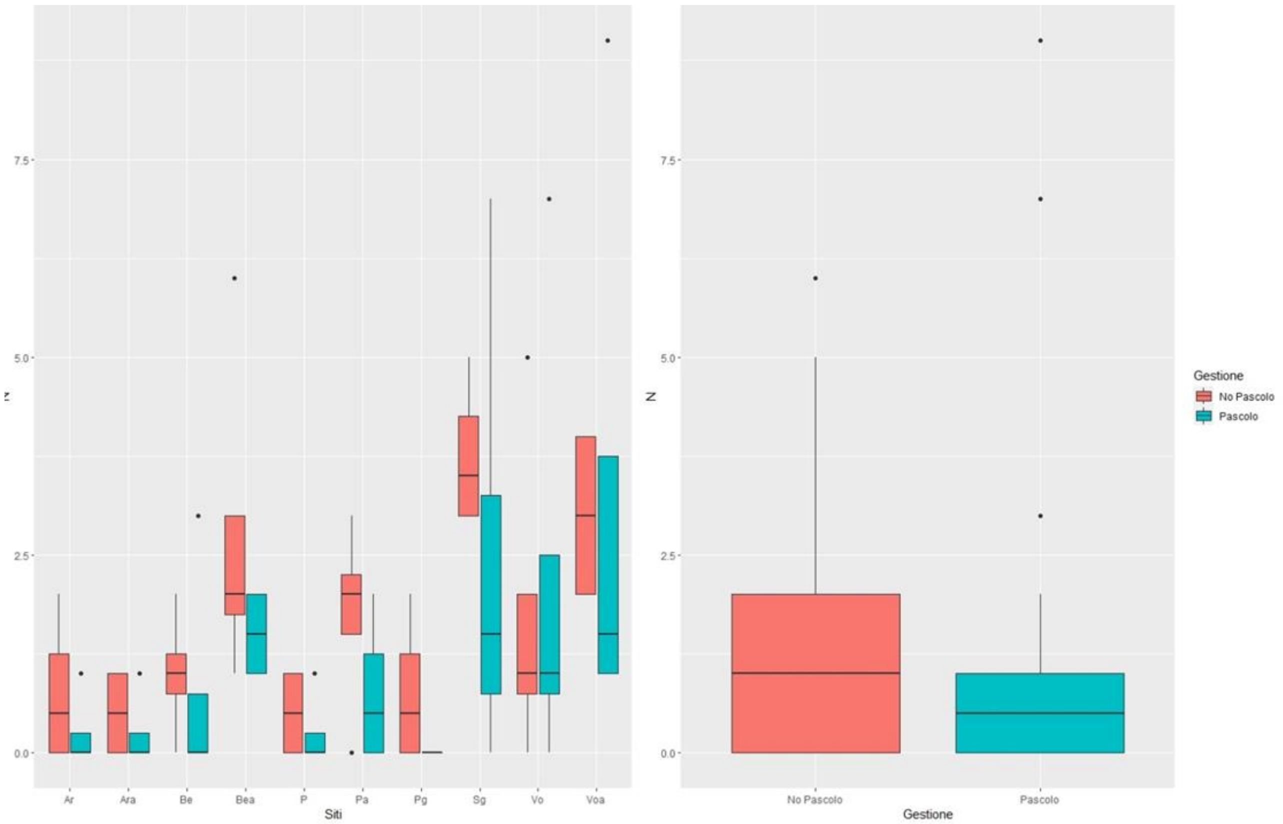


Fig. 10.a and **10.b.** Total abundance of hoverflies in ungrazed and grazed areas for each site (on the left) and total abundance in ungrazed (red) and grazed (green) areas for all the sites (on the right) in 2021

The partial results of 2022 show that total abundance and species richness are quite similar in both grazed and ungrazed areas.

Considering all years and sampling sessions, the abundance in the ungrazed area is slightly higher than in the grazed area but the difference between them is not significant. Adult hoverflies are mobile species and move in search of nectar: managed and control areas are probably too close together to notice a significant difference.

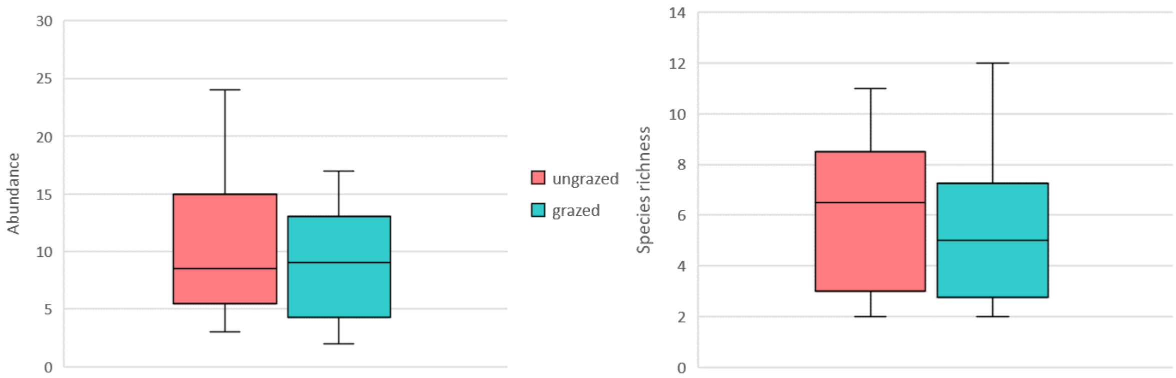


Fig. 11.a and **11.b** Total abundance (above) and species richness (below) in grazed and ungrazed areas for hoverflies in 2022

Moreover, in 2021, two **emergency traps** (1,33 m^2 each) were set in each study area, one in the managed area (grazed) and one inside the exclusion fence (ungrazed). The traps were activated from mid June to mid September, every 15 days the samples were collected and once a month the traps were moved by a few meters.

All the collected material was identified at family or super-family level while *Diptera Syrphidae* were identified at species level. In total, 105 taxa were identified and the total abundance of insects in the grazed areas was significantly higher than in the ungrazed ones.

Fig.12. Total abundance of insects sampled with emergency traps in grazed (green) and ungrazed (red) areas.

Considering potential pollinators, abundance was significantly higher in the grazed patches.

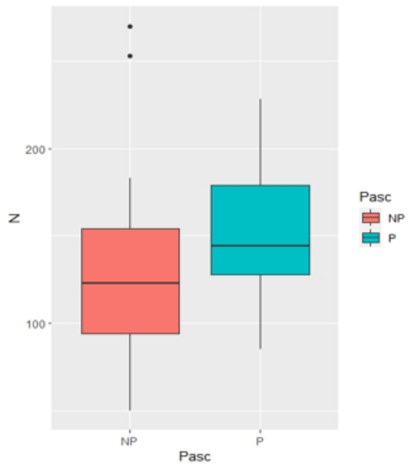


Fig. 13. Abundance of potential pollinators in grazed (green) and ungrazed (red) areas.

Regarding *Diptera Syrphidae,* 15 species were identified. In particular, *Cheilosia subpictipennis* and *Cheilosia laeviseta* are interesting findings since these species are typical of alpine habitats but very rare. This group showed higher species richness in the grazed areas.
Moreover, in terms of taxa diversity, no significant differences can be observed regarding patch management.
In conclusion, the effects of low density grazing seem to have a positive or non relevant effect on invertebrate biomass, but at the same time it is important to maintain ungrazed patches as nectar sources for adult pollinators.

Bumblebees have been monitored since 2017 in Noaschetta Valley. Monitoring was carried out at two levels: i) landscape-scale communities, to get an idea of the species characterizing each of the 10 areas investigated; ii) local-scale habitat use, to get an idea of the occurrence of different species in grazed and non-grazed areas and to record the link with the floristic species present.

(i) Landscape-scale communities.

Sampling was done monthly from July to September through opportunistic transects, one for each selected area, lasting 30 minutes.

(ii) local-scale habitat use.

Sampling was conducted biweekly from July to September through two opportunistic transects per selected area, one inside the non-grazed area (fenced) and one outside, in the grazed area, both lasting 10 minutes. In addition, a survey of exclusively flowering vegetation was also conducted in these areas for each sampling, following the Braun-Blanquet method.

In both cases, individuals were captured with entomological nets, determined in the field and then released, with the exception of the doubtful specimens that were taken and determined in the laboratory.

(i) Landscape-scale communities.

A total of 19 species have been found over the years. Of these, two have always been particularly abundant: *Bombus soroeensis* and *Bombus ruderarius*. Of particular interest was a specimen of *Bombus alpinus* found in 2019 in the highest plot of the valley (1900 m a.s.l.).

(ii) Habitat use at the local scale.

Here are some results from the last years consearning Pian Sengio, the lowest plot of the area (1470 m a.s.l.) and the first to be grazed in summer.

Below are graphs where we can observe the differences in abundance between the grazed and ungrazed area.

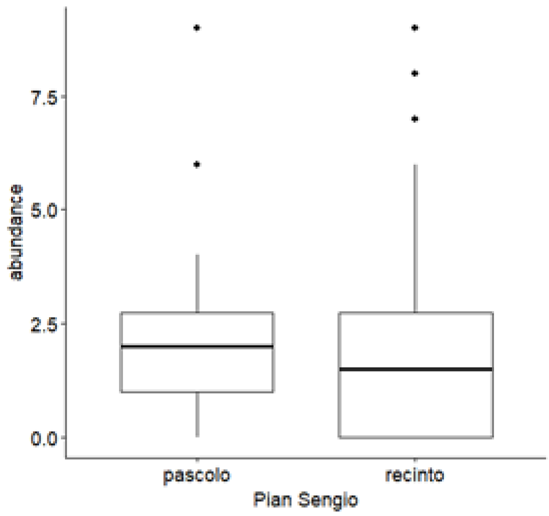


Fig. 14. Abundance outside (left) and inside (right) the exclusion fence in Pian Sengio

Considering all years and sampling sessions the abundance in the grazed area (pascolo) is slightly higher than the one in the non-grazed area (recinto), but the difference between them is not significant.
The data are then divided per month (still considering all the sampling years together), considering that the grazing will take place between July and the beginning of August.

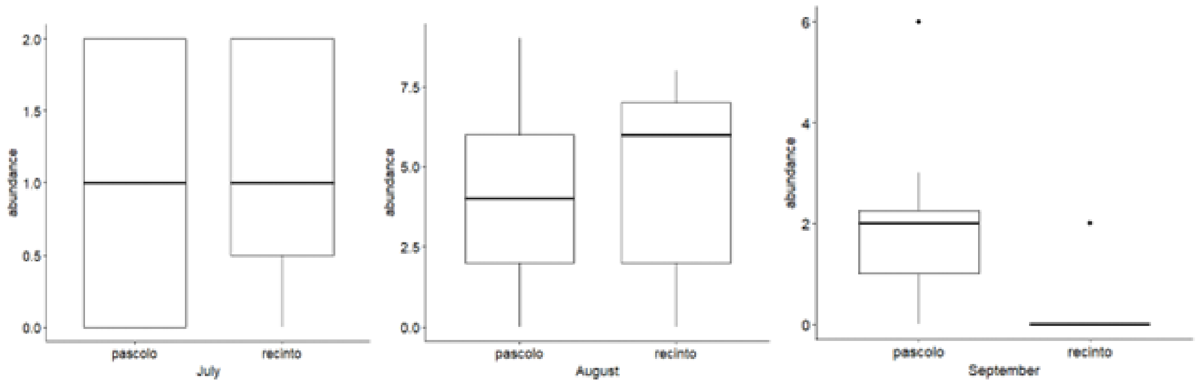


Fig. 15 Total abundance divided per month.

We can see how in July the abundance of bumblebees inside and outside the fenced area are quite similar as there will be not much difference in the abundance of flowers. In August, during grazing or just after it, the bumblebees will be using mostly the non-grazed area as it still has flowering plants. In September the situation changes, the area that was once grazed will be full of flowers again, while the plants in the non-grazed area will have reached maturation and no longer have flowers.
This pattern shows us the importance of having and preserving a heterogeneous area to preserve pollinators, like bumblebees.

MRR to study habitat use in bumblebees

The spatial dynamics of bumblebees are particularly relevant for pollinator conservation because they provide a proxy for assessing the impact of landscape changes, habitat fragmentation and human activities also on other taxa.
Based on this, a mark-release-recapture (MRR) study was carried out to investigate the spatial use of bumblebees with a focus on movements between patches and the distribution of sexes and species groups within sites. Monitoring was carried out in 2020 and 2021.
In 2020, the activities took place from 5 to 9 August (five consecutive days of intensive sampling) in five semi-natural open areas (patches). The patches were chosen because they are linked by a spatial continuum and are easily accessible (Fig. 16.a). Sampling involved the simultaneous monitoring of all patches (from 11:00 to 17:00). Once captured, the bumblebee was placed and delicately secured in a plunger cage and marked on the thorax with a specific site colour (Fig. 16.b). Captured or recaptured individuals were placed in special containers so that they would not be recaptured during the same sampling session. At the end of sampling, individuals set aside were released. The floristic species on which the bumblebees were captured were also recorded and the bumblebees themselves were divided into groups of species, based on the terminal colouration of their abdomen (red, white and yellow-orange).

Fig. 16.a and 16.b. Patches for MRR (left), marking operations of an individual (right).

In 2020, 1’626 individuals were captured and marked (599 females, 1’027 males). The study area has an average density of about 200 individuals per hectare (D = 197.83±30.01). The number of bumblebees recaptured was 488 (recapture rate = 30%).

Only eight recaptures were from other patches. This data further demonstrates a phenomenon already known in the literature, i.e. bumblebees strong site fidelity. It is likely that the sites examined have such a good availability of nectar plants that the search for new sources towards other patches is not stimulated. Another factor detrimental to possible dispersal could be the environmental matrix in which the patches are immersed, many of which are divided by obstacles such as forests and rock walls. However, this hypothesis would seem to be disproved by an exchange of 3 individuals between the most distant sites with many natural barriers between them (Fig. 17). Although the numbers are very low, these observations are an indication of how some individuals of bumblebees manage to travel considerable distances (900 metres as the crow flies) through numerous obstacles.

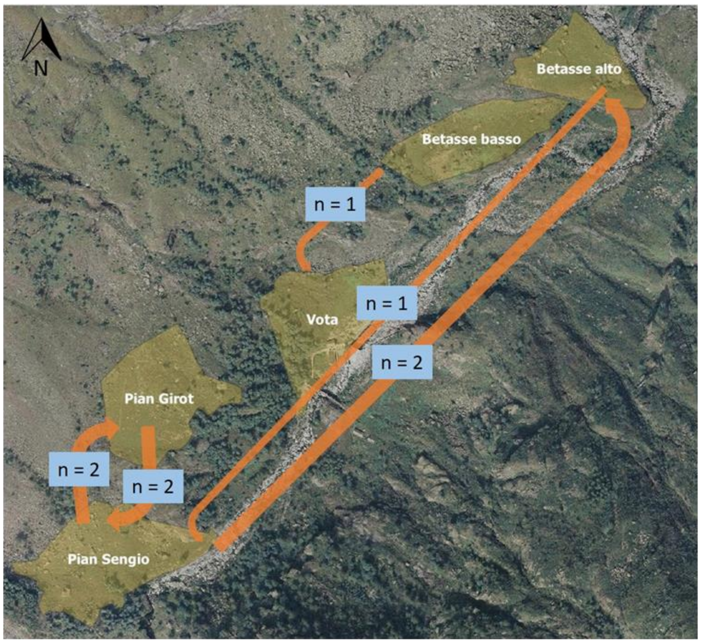


Fig. 17. Movement between patches. The orange arrows indicate movements between patches while the thickness is proportional to the number of individuals that moved (2020 sampling season).

For each species group, floral preferences were calculated and any differences between males and females were highlighted. It emerged that for males, two floristic species are preferred (*Cirsium palustre* and *Rubus fruticosus*; Fig. 18.a). Many females also exploit these two species, but the percentage of males is markedly higher.
Concerning species groups, clear differences in preference were found. The species most preferred by the "red bumblebees" is *Cirsium palustre* (Fig. 18.b). Two other species most preferred by the "red bumblebees" belong to the genus *Epilobium*. The "white bumblebees", on the other hand, prefer *Angelica sylvestris* and *Rubus fruticosus*, while the "yellow-orange bumblebees" show a clear preference for *Trifolium pratense* and *Galeopsis* gr *tetrahit*.

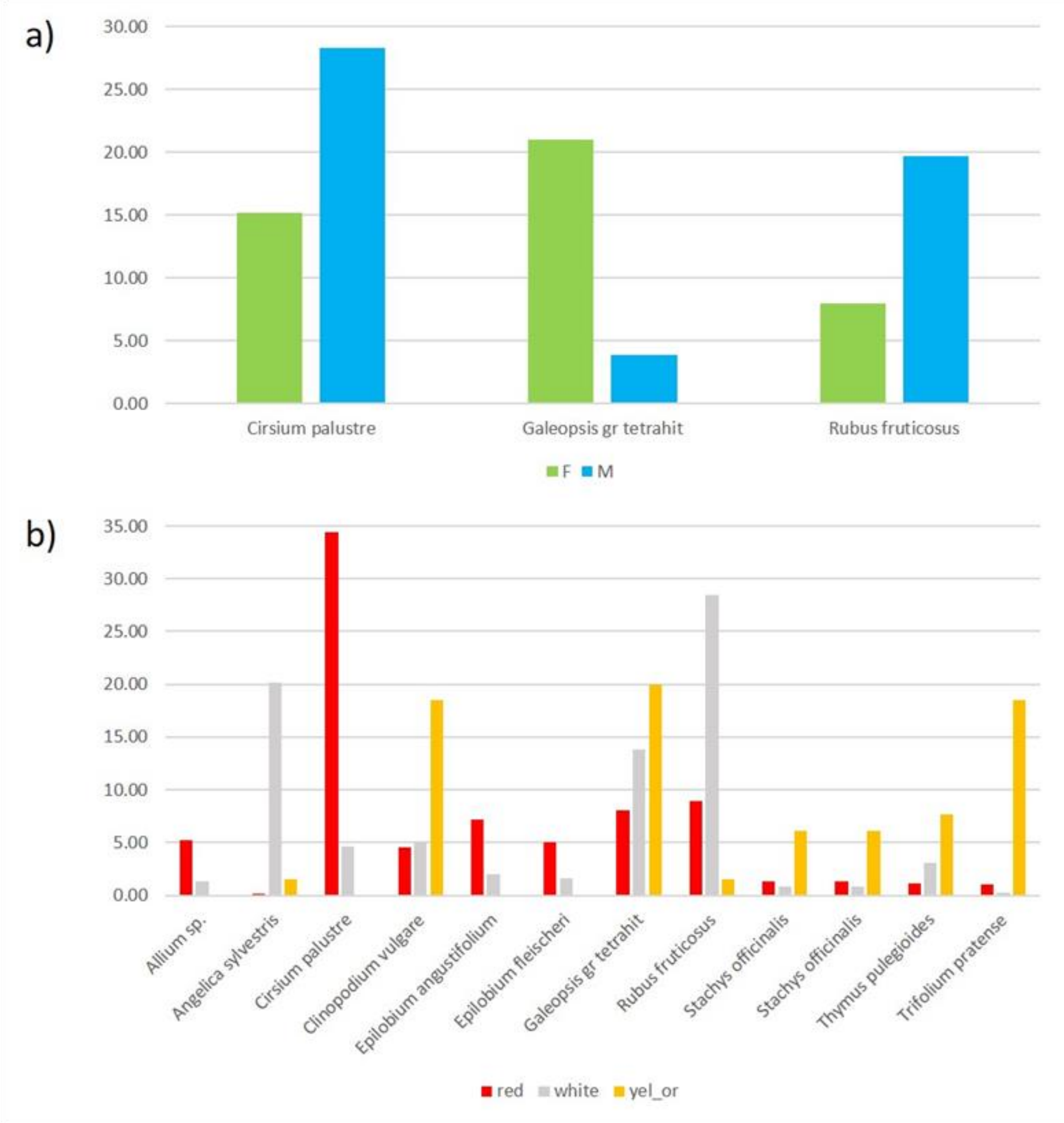


Fig. 18.a and 18.b. Histograms with percentage of individuals on preferred flowers divided by sexes a) and by species groups b). Data from 2020.

These first results show that the species groups are diverse in terms of floral preferences, providing insights into the ecology of bumblebees and showing the importance of ensuring heterogeneity at both landscape and patch levels.

In 2021, the main objective of the MRR study was to evaluate the direct effect of grazing on bumblebee movement and patch use. Indeed, it was hypothesised that a decrease in floristic resources due to grazing could force bumblebees towards areas with greater floral availability. Therefore, activities took place over two two-day sampling sessions (10-11 August and 17-18 August) in the five patches of 2020. The first sampling day (t0), involved intensive sampling of a focal patch (Vota). The following day (t1), sampling operations involved all five patches. After the first session (t0 and t1), a break was taken during which, by prior arrangement with a shepherd, the grazing planned for the focal patch was carried out. After the break, on 17th August (t3), another intensive session was carried out in the focal patch, using a different colour for marking than the previous intensive sampling, while on the following day (t4) all patches were examined at the same time to check for any movement from the grazed site.
During the study, 1’300 individuals (800 females, 497 males) were marked. Bumblebee movements between the Vota focal patch and other patches were few. In particular, between t0 and t1 there were 6 movements while between t1 and t3, the period in which grazing impacted the Vota focal patch, only 5 bumblebees moved. However, between t0 and t2, i.e. after grazing in the Vota patch, we recorded a drastic decrease in bumblebee abundance (from 298 to 68 contacted bumblebees).
Therefore, a decline in floristic resources could lead to a local decline in bumblebee abundance. But unfortunately, we cannot determine whether this decline depends on movements to other areas. The few observed movements may be due to high bumblebee mortality. Or, the patch system is not closed and the bumblebee of the focal patch moved to other un-sampled areas. Although the selected patches are well delimited by natural barriers (e.g., closed environments, rock walls, streams), other potentially suitable grassy slopes are present further away from the study sites.
However, it was important to note a strong difference from 2020, a year in which high site fidelity was evidenced with little bumblebee movement among sites. These results therefore again allow us to consider how important it is to analyse the impact of grazing at the landscape level, ensuring environmental heterogeneity and connectivity between areas.

To monitor ***<u>surface-active macro-invertebrates</u>***, in each study area, we positioned 3 traps inside the fences (ungrazed areas) and 3 traps outside (grazed areas). We collected them every 15 days, from July to September, in 2018 and in 2019. We analysed carabids (*Coleoptera Carabidae*), staphylinids (*Coleoptera Staphylinidae*) and spiders (*Araneae*), selected as potential indicators of grazing pressure.

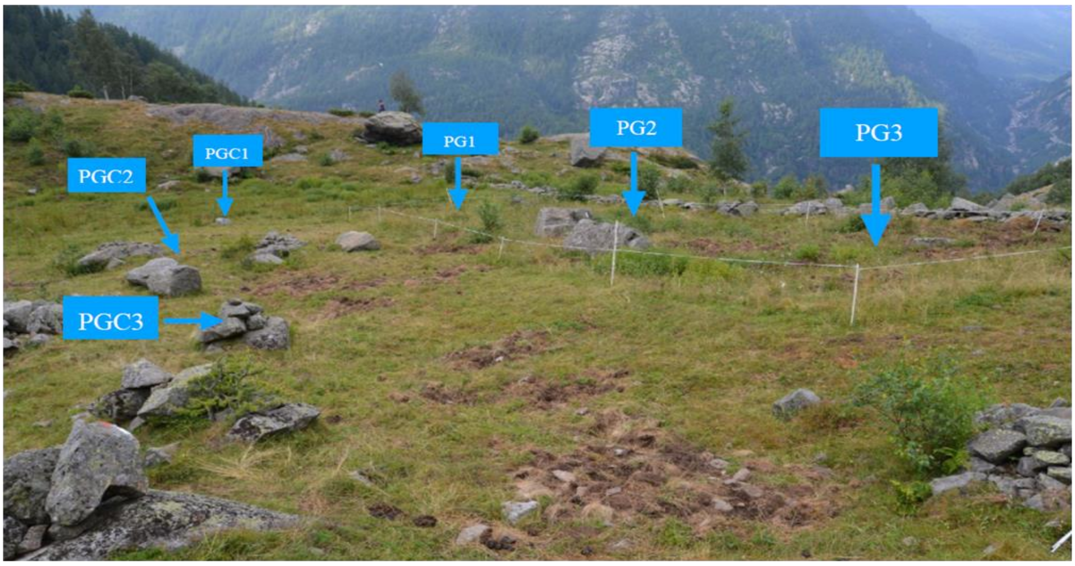


Fig. 19. Traps’ position inside and outside the exclusion fence.

Concerning ***carabids***, we found **32 species**, collecting 2’644 individuals. Most of the individuals are represented by 3 species, *Pterostichus flavofemoratus* (n = 1’697), *Poecilus versicolor* (n = 356) and *Calathus melanocephalus* (n = 276), which are quite tolerant and insensitive to habitat alteration. These generalist and olfactory-tactile predator species can benefit from grazing, sometimes even intensive grazing that creates an overabundance of prey (including collembolus, for example), as they have no special trophic needs and can easily find food. All these three species didn’t show any clear pattern of presence between grazed and ungrazed areas. Moreover, analysing data at community level, we did not find any difference between grazed and ungrazed areas, both in terms of abundance (t-test for paired data, n = 10, t = -0.268, p = 0.786, n permutation = 999) and species richness (t-test for paired data, n = 10, t = -0.651, p = 0.581, n permutation = 999).

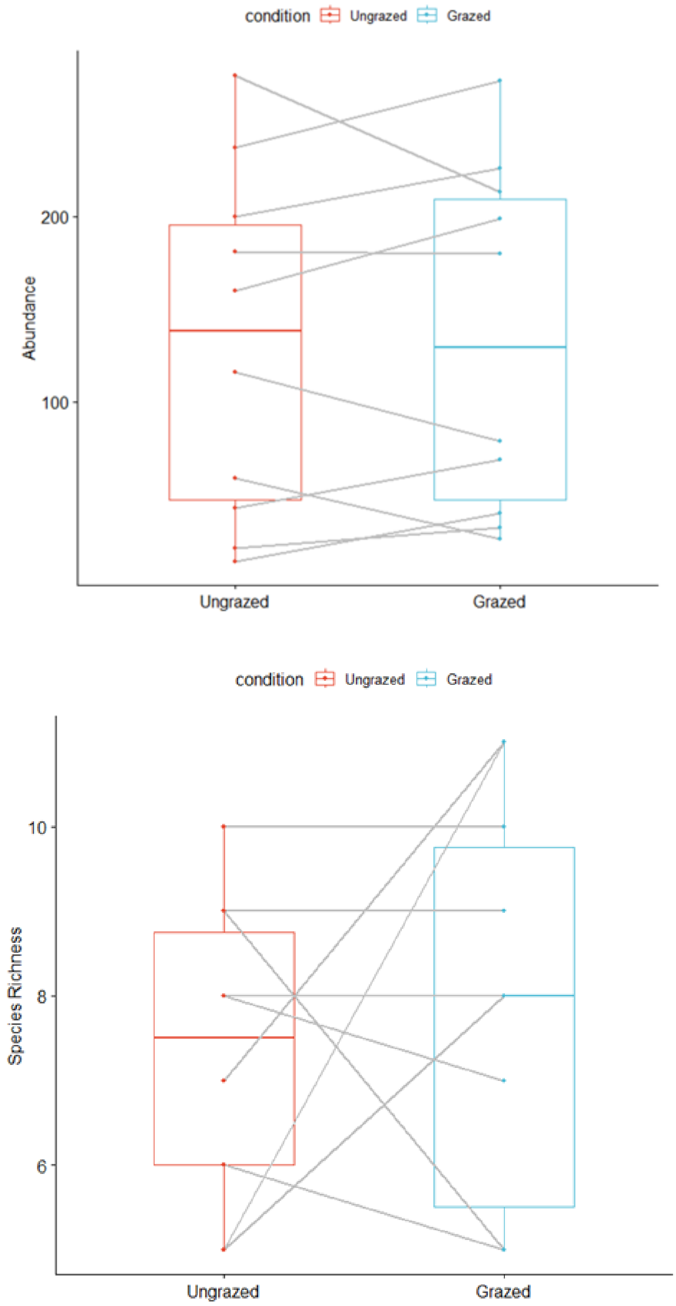
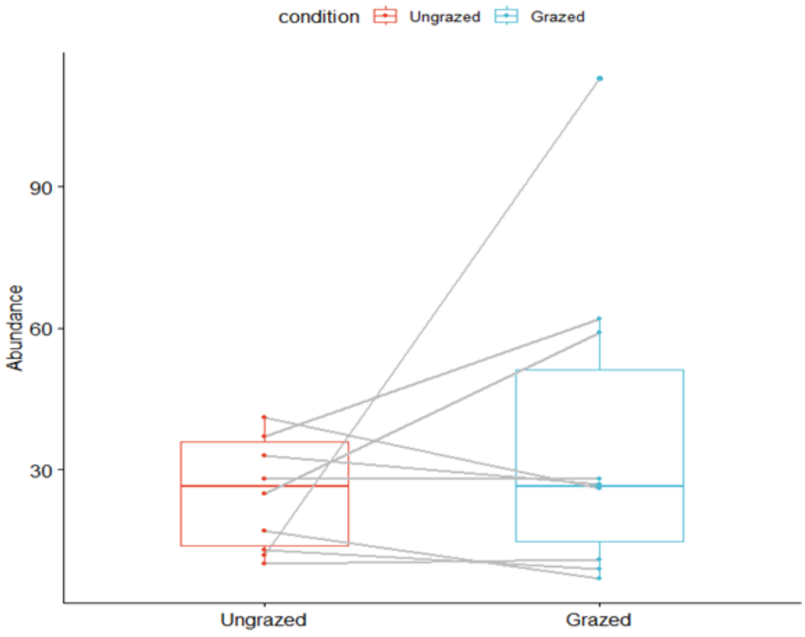


Fig. 20.a and 20.b Abundance and species richness of carabids in the grazed and ungrazed patches

Concerning ***staphylinids***, we also found **32 species**, collecting 625 individuals. And also in this case, the sampled communities are dominated by a few species, in particular *Dinothenarus fossor* (n = 170) and *Philonthus cognatus* (n = 146). Also in this case, we did not find any difference between grazed and ungrazed areas, both in terms of abundance (t-test for paired data, n = 10, t = -0.988, p = 0.499, n permutation = 999) and species richness (t-test for paired data, n = 10, t = -0.638, p = 0.602, n permutation = 999).



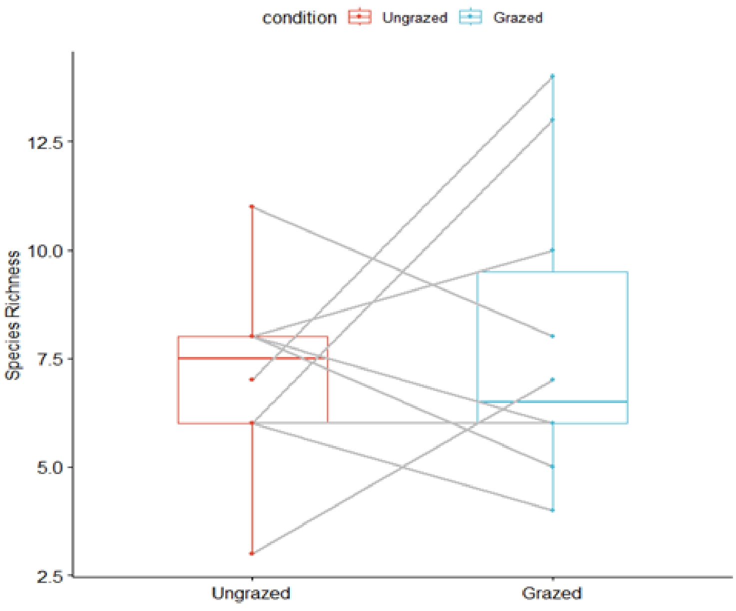
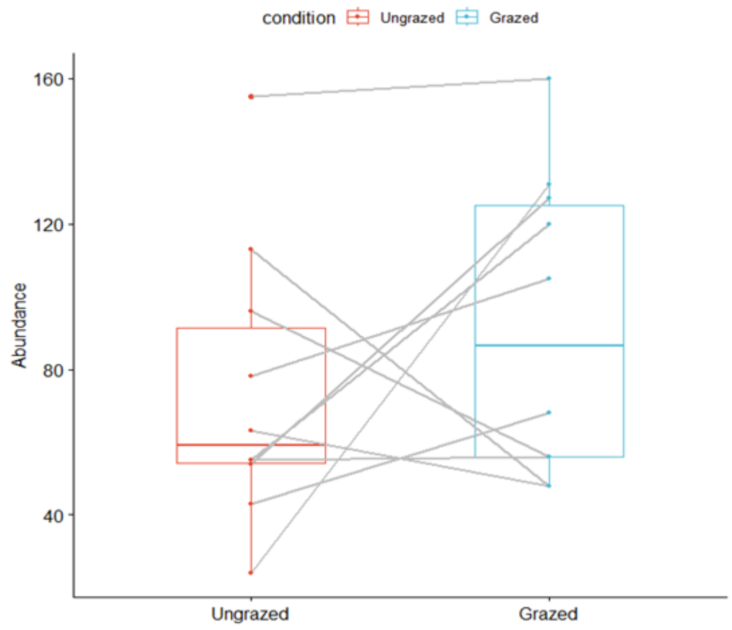


Fig. 21.a and 21.b Abundance and species richness of staphylinids in the grazed and ungrazed patches

Concerning ***spiders***, we found **55 species**, from 1’655 individuals. In the case of spiders, communities are a little bit more equilibrated than for the other monitored macro-invertebrates, but we observed some dominant species belonging to the genus *Pardosa* (i.e., *Pardosa riparia*, n = 689; *Pardosa torrentum*, n = 251; *Pardosa blanda*, n = 169; *Pardosa palustris*, n = 167). Also for spiders, we did not find any difference between grazed and ungrazed areas, both in terms of abundance (t-test for paired data, n = 10, t = -1.096, p = 0.306, n permutation = 999) and species richness (t-test for paired data, n = 10, t = 0.075, p = 0.942, n permutation = 999).



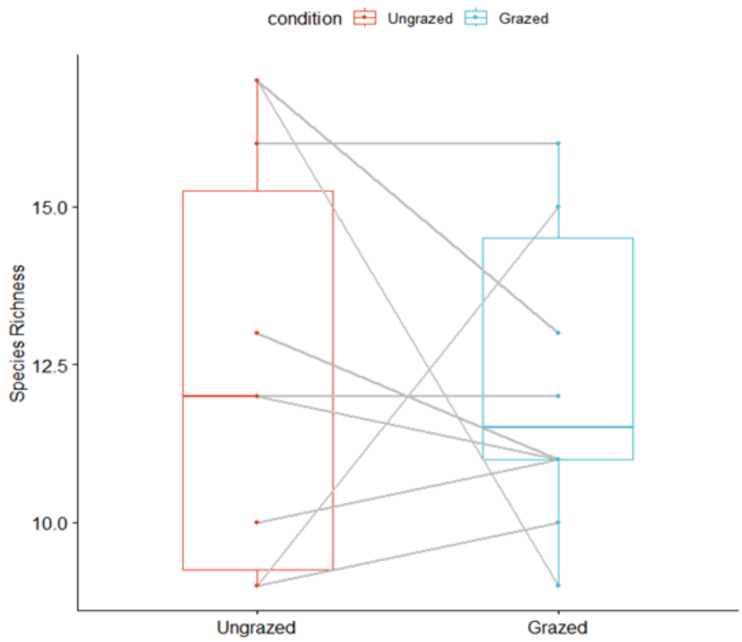


Fig. 22.a and 22.b Abundance and species richness of spiders in the grazed and ungrazed patches

To sum up data from <u>***surface active macro-invertebrates***</u>, we can assess that there is no pattern between grazed and ungrazed areas: differences are probably too highly dependent on site-specific characteristics and no clear inferences can be drawn. Moreover, in all three taxa, we observed communities dominated by a few abundant species, usually generalist and widely spread inside the study area. Surface-active macro-invertebrates cannot be considered good indicators of differences in grazing regimes at this spatial scale of analysis. In any case, periodically repeating such kind of monitoring can show us if future communities will continue to be dominated by the same species or, thanks to our applied donkeys grazing, they will become more equilibrated.

We monitored <u>***butterflies***</u> with linear transect (length 200 m), every 15 days, from the middle of June to the beginning of September (2018-2022). We recorded a total of <u>**85 species**</u> above all the five years: we observed yearly fluctuations both in species richness (annual species richness = 67 ± 1.6) and in abundance (annual abundance = 1271.4 ± 136.6). Among the observed species, we also recorded species protected at the European level (i.e., *Maculinea arion* and *Parnassius apollo*), which are quite abundant and spread in the study site. Moreover, we observed species quite rare elsewhere in the Park, such as *Apatura iris* and *Lycaena alciphron*. It is also important to notice that the communities identified are heterogeneous from the functional point of view, meaning that the study site is characterised by well-structured communities and that the grazing activities allow their persistence, without eroding the most sensitive species. Indeed, such data are an important starting point to characterise the community composition of the grazed plots and serve as a fundamental baseline to understand if the grazing activities are effective in maintaining the species and functional diversity of the study area.

2.3.1 Vegetation monitoring

The ecological and vegetational framework of the Noaschetta Valley was defined using different survey methods.
Firstly, the phytosociological aspects were studied using the Braun Blanquet method sampling two squares for each sampling area, one inside and one outside the exclusion fence (20 squares in total, 36 m^2 each). Among the different habitats identified, eleven can be attributed to Natura 2000 classification. In order to investigate the vegetation more deeply, in the same areas 20 squares (50x50 cm) were set and the sampling was carried on using a grid made of 25 centimetric cells. All the species in the centimetric cells were identified and recorded, in addition the dominant species was detected. According to the results obtained by these samplings together with past surveys, no floristic emergencies are present in the area. However, some plants of *Drosera rotundifolia* were found near one of the sampling area (Arculà).
Secondly, to evaluate the physiognomic change in time of the vegetation structure six transects (20 m long and 2 m large) were conducted noting the phytocoenosis and measuring the heights of the trees insisting on the transect.
To investigate the vegetation structure and the relations between herbaceous species with shrubs and trees, together with the physiognomic transects, two UAS flights were realized, in Gran Prà (Varda-Muracce) pastoral district and Noaschetta pastoral district, respectively. The surveys were carried out with an A.P.R. model DJI Mavic 2 Pro (category VL/mc according to the ENAC regulations in force), equipped with a camera capable of taking photographs with a resolution of 20 Mpx. The shots aimed at photogrammetric reconstruction were taken by performing flight crawls with a serpentine path. Totally, 1476 frames were acquired to cover the study area of Varda-Muracce, and 478 photographs were taken for the Noschetta area; all the frames acquired were processed for photogrammetric processing with dedicated software (SFM software Structure From Motion). The photographs were taken continuously, guaranteeing between one image and the next an overlap of no less than 85%. The shots aimed at the first survey were taken both with nadiral orientation and with an oblique lens (80° with respect to the horizon), while the Noaschetta area was surveyed with exclusively nadiral shots due to its different morphological characteristics; the choice of this survey mode allowed a high degree of detail and the best three-dimensional reconstruction to be obtained. The survey of the Varda-Muracce area covered a portion of territory of approximately 40 ha, while the survey of the Noaschetta Valley covered a portion of approximately 50 ha. The following documents were produced from the photogrammetric processing:

- Geotiff georeferenced orthophotomosaic (resolution 3 cm/pixel)

- DEM Digital Elevation Model geotiff (resolution 12 cm/pixel Varda-Muracce and 5 cm/pixel Noaschetta area).

Fig. 23. Example of a drone image

To sum up:

The use of donkeys in this context seems to be a good system against reforestation and encroachment, but more years are needed to be really effective. The system of water management and the restoration of watering points allow also the use of historical grazing areas at low altitude. In particular, it makes possible to organise a more rational grazing by using water as a point of attraction in order to make the forage resource more evenly consumed and to proceed by directing the accumulation of faeces to less fertile areas.

The comparison in terms of biodiversity of grazed and ungrazed areas allow us to directly obtain a measure at local scale, to be compared with the effect of sustainable grazing at large spatial scales in the long-term.

Also the presence of small ungrazed areas can represent an important food source for pollinators and other invertebrates. A biodiversity-friendly use of pasture could precisely be to manage grazing in rotation sectors over the years, so as to achieve the desired effects on the vegetation (from an agronomic point of view) and to favour biodiversity allowing pollinators to complete the life cycle.

3. The management plans

Five technical documents were produced in the PNGP to define guidelines for the management of pastures in three test sites of the Piedmont region (districts: Noaschetta, Dres and Gran Prà) and two in Aosta Valley Autonomous Region (pasture district of Fos-Fond in Rhêmes-Notre-Dame and pasture district of Goilles-Etzelley-Bardoney in Cogne) and two in Aosta Valley Autonomous Region (pasture district of Fos-Fond in Rhêmes-Notre-Dame and pasture district of Goilles-Etzelley-Bardoney in Cogne). These guidelines address all the main topics that are important to arrive at a rational pasture management that takes into account the effects of climate change. The documents frame the territory from an orographic and climatic point of view, after which they analyse the pastoral vegetation, dealing with possible habitats and species of conservation interest. Thanks to the map of pastoral types, realised in the frame of the action C.2, it was possible to calculate the ideal stocking rates, while a focus on past management and the vulnerability of the area to climate change is indispensable for the definition of management practices and technical adaptation strategies. The guidelines differentiate the pastoral sectors into areas of spontaneous evolution, for conservation, improvement, recovery, and identify the most opportune grazing techniques. Finally, they deal specifically with adaptation strategies pursued through managed grazing (Annexes II-III-IV).

Fig. 24. Covers of the three technical documents produced