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Biodiversity monitoring in the NW Italian Alps: state and expected changes

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Introduction

Mountain ecosystems are considered 'biodiversity hotspot' due to the huge quantity of endemic and vulnerable species and because they have already experienced exceptional losses (GRABHERR et al. 2011). As a result, alpine ecosystems have been identified as being particularly at risk from predicted changes and are likely to show their effects earlier and more clearly than many others. This underlines the need to monitor alpine biodiversity and identify the factors that influence its distribution.

In this framework, in 2006, 3 alpine parks in NW Italy (Gran Paradiso National Park GPNP, Orsiera Rocciavrè Natural Park ORNP, Veglia Devero Natural Park VDNP) started a field project to determine the factors influencing animal biodiversity and to identify the most appropriate methods for a periodically repeatable monitoring.
Main objectives are:

- to **measure the biodiversity status,** describing animal biodiversity along altitudinal gradients in space and time. This is fundamental for creating a baseline against which to identify future changes and for planning highly focused conservation actions;
- to **forecast the biodiversity status**, for estimating the risk of biodiversity loss, also through the application of environmental change scenarios. This will allow to identify the threshold beyond which the risk of biodiversity loss will be extremely elevated and to identify potential 'vulnerability and safety'.

Methods

12 altitudinal transects (from montane to alpine belt) were chosen. Each transect was composed of 4-7 sampling units separated by an altitudinal range of 200 meters (69 plots; Fig. 1). In every station were collected data for 5 taxa (Lepidoptera Rhopalocera, Aves, Coleoptera Staphylinidae, Coleoptera Carabidae, Araneae*),* census by standardized, repeatable and cheap methods. Each sampling station was also characterized by topographic, environmental and micro-climatic (temperature) parameters.

This research can offer a representative sample of NW Italian Alps and it is a long-term monitoring project, with two years of sampling every five years. The first sampling season occurred in 2006-2007 for GPNP and in 2007-2008 for ORNP and VDNP; the second sampling season occurred in 2012-2013 and the next one is expected to be in 2018-2019.

Results and Discussions

1. Measure the biodiversity status

In VITERBI et al. *2013*, the analysis of data coming from the first sampling season, showed that **species richness** is mainly determined by altitude and temperature (Variation Partitioning for all taxa pooled together: the relative importance of altitude is 40.9% and of temperature is 45.3%).
The species richness of all taxa pooled together presents a **hump-shaped** relationship along the altitudinal gradient ($\ln(S) = 2.841 + 0.002\ \mathrm{Alt} - 6.420 \cdot 10^{-7}\ \mathrm{Alt}^2$; $D^2_{adj}=0.425$; $p<0.0001$), with a peak around 1500 m a.s.l., corresponding to the subalpine belt (Fig. 2).

On the opposite, the proportion of **endemic and vulnerable species** significantly increases from the Montane to the Alpine belt (K-W test, N=69, d.f.=2; $H_{endemic}=30.085$, p=0.0001; $H_{vulnerable}=34.633$, p=0.0001), showing how the highest altitude of our gradient is species poor but characterised by species of conservation concern.
We carried out first comparisons between the two sampling seasons for *Lepidoptera Rhopalocera* (2006-2008 *vs* 2012-2013), analysing changes through space and time and trying to identify species or functional groups responsible of changes.

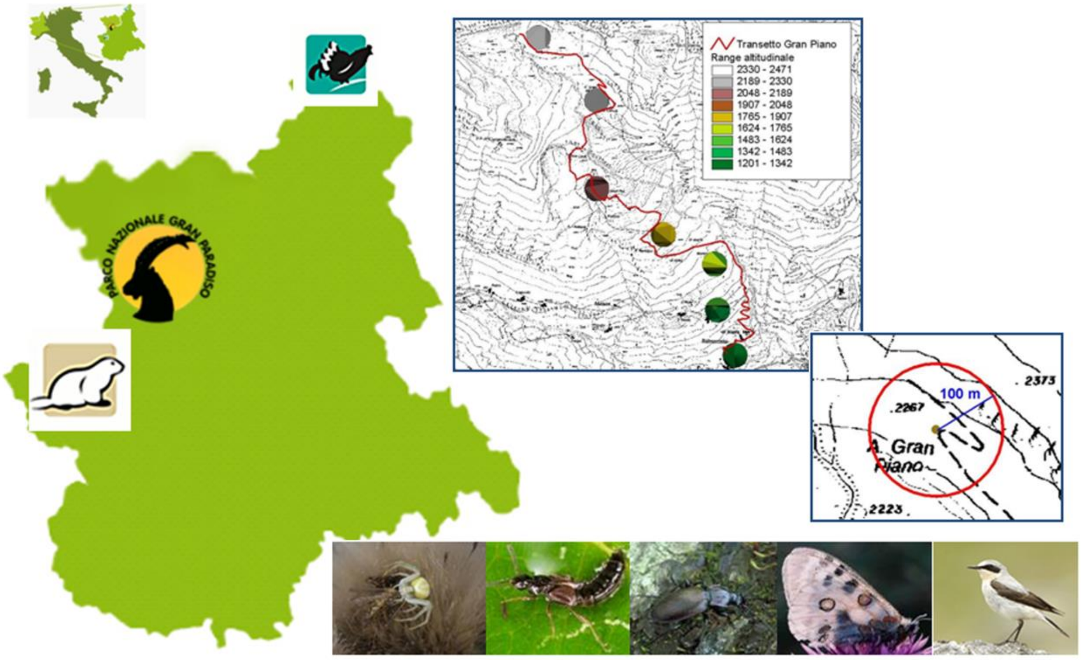

Figure 1: Study areas. 69 plots distributed along 12 altitudinal transects in 3 parks in NW Italian Alps (from S to N, ORNP, GPNP, VDNP). In each plot, 5 taxa (from the left, *Araneae, Coleoptera Staphylinidae, Coleoptera Carabidae, Lepidoptera Rhopalocera, Aves*) were sampled and topographic, environmental and micro-climatic parameters were recorded.

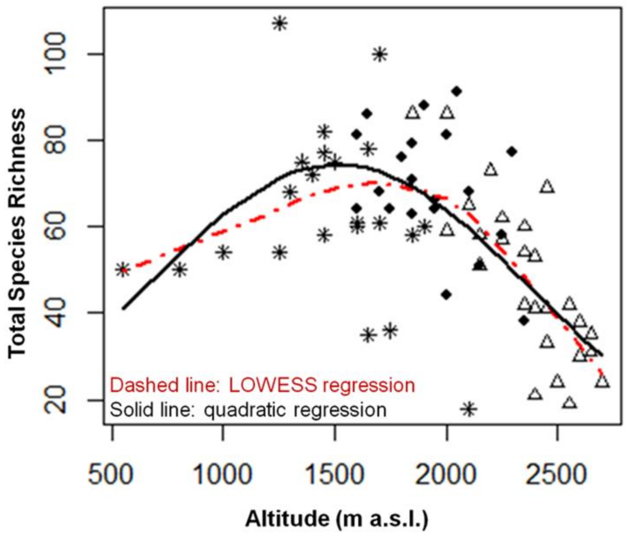

Figure 2: Scatterplot of the total Species Richness per site along the altitudinal gradient (from VITERBI et al. 2013).

140 species were shared between the 2 sampling sessions, with 146 species in the first one and 149 species in the second one. Focusing on changes, five years later only, we observed a general **increase** in mean **occupancy level** (number of plot per species; mean change=3.95±0.50, t=-7.90, p=0.001) and in **species richness** (mean change =10.32±0.86; t=-11.94, p=0.001).

Changes differed across species and occupancy didn't increase equally among ecological groups:

- concerning **feeding specialization**, specialised (monophagous) species significantly differ (mean change=-2.00±1.15, KW, $\chi2$=8.61, p=0.035);
- regarding **altitudinal specialization**, altitudinal specialists (KW , $\chi2$=9.17, p=0.010) and strictly alpine species (MW, W=880, p=0.014) showed a significantly lower change than compared with the other ecological groups.

Overall community composition didn't change, but we observed an increase in shared species and a tendency towards homogenisation (Analysis of Dispersion in Community Composition, F-value=13.15, p-value<0.001).
For each species, we calculated the **Species Temperature Index**, obtained combining species' distribution in N Italy (Balletto et al. 2007) and temperature data (Metz et al. 2014). The analysis of changes in Community Temperature Index (CTI) between sampling seasons showed that it significantly increased (t=-3.59; p=0.001) and that its changes was mainly dependent on the geographic position of the sampling plots (linear regression, model selection through AICc; $R_{squared}$=14.17, p=0.007; Protected Area, p=0.007). Indeed, in the protected area characterised by the lowest mean temperature we observed the highest increase in CTI (Fig. 3).

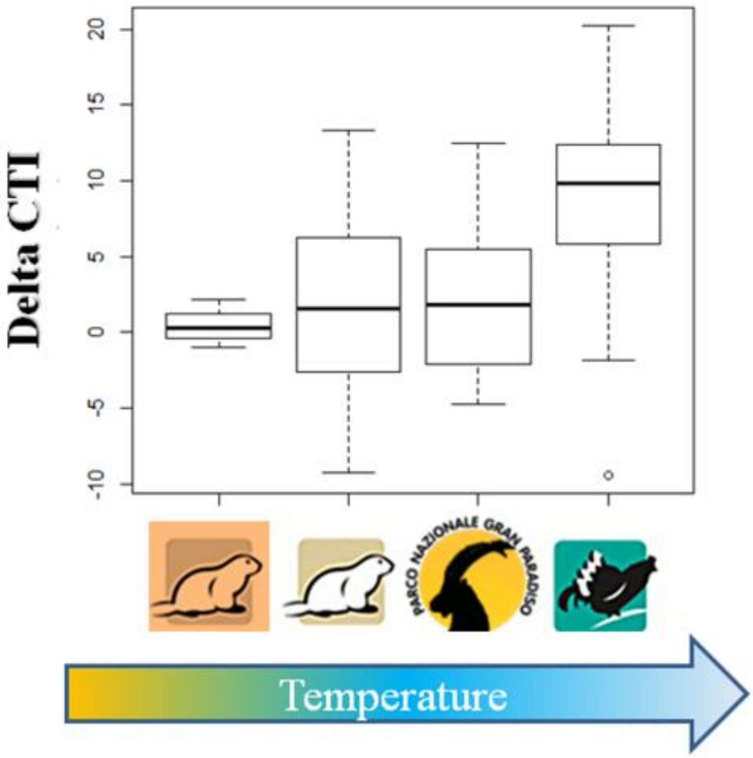

Figure 3: Variation in Community Temperature Index between sampling sessions (first sampling session *minus* second sampling session) as a function of protected areas. From left to right: Foresto xerothermic oasis (xerothermophilous area inside ORNP), ORNP, GPNP, VDNP. The protected areas are ordered from the warmest to the coldest, concerning seasonal air temperature. As can be seen, in the coldest protected area was recorded the highest increase in CTI.

2. Forecast the biodiversity status

Species Distribution Models (SDM) represent essential tools to forecast impact of temperature changes and to develop adequate conservation strategies.

In this framework, we applied presence-only distribution models (Maxent; Philips et al. 2006) to species distribution data. Purpose of our work is to evaluate the effects of a moderate increase of temperature (*'what if'* scenarios based on literature data) on multi-taxa distribution, described in term of alpha and beta diversity at plot scale.

Our results show small changes in biodiversity patterns but different responses of species, depending on the taxonomic group and the degree of specialization. In particular, we observed an increase in plot occupancy and in species richness in butterflies, whereas endemic and vulnerable species showed a pronounced decrease if compared with the all the other species.

Moreover, models agree that changes in species richness may be particularly significant in the alpine belt. Community composition changes in a coherent way and the alpine and the subalpine belts became more similar to the low altitude ones (Wilcoxon test, p<0.01; Fig. 4). Nevertheless, the gradual but clear separation among vegetation belts is still retained after temperature increase scenarios.

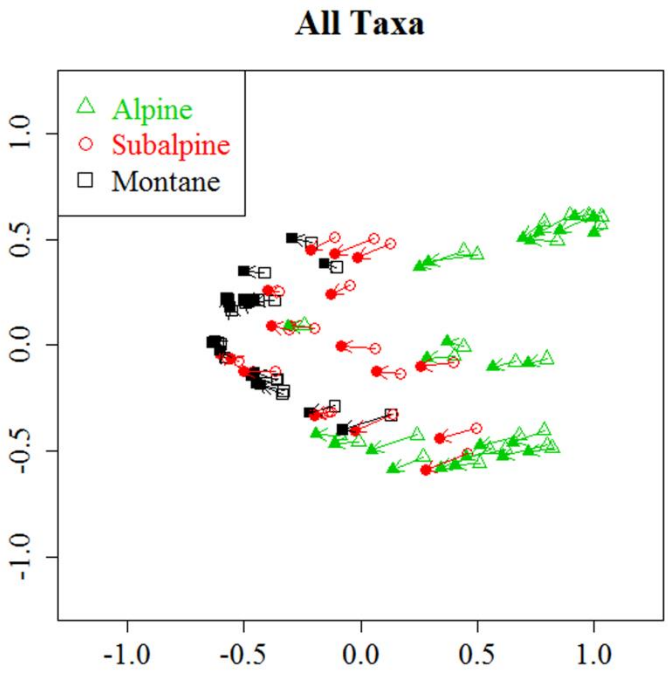

Figure 4: Correspondence Analysis for all taxa pooled together. Empty symbols indicate present situation, filled symbols the projected one. Arrows indicate shift of each plot. First axis is positively correlated with altitude and negatively with minimum temperature.

Conclusion

This study allows to assess the coherence in the distribution of different taxa along altitudinal gradients and the influence of geographical, environmental and climatic factors on biodiversity, as a baseline against which measure future changes. Our results suggest that alpine biodiversity should be deeply monitored in the long term both for early warning signs of climate change and both as empirical tests of predictions. Protected areas can be used as a litmus test of any changes. To play this role parks need to share long term monitoring programmes that allow to measure biodiversity status (species richness and distribution, community composition, functional diversity), to underline the climatic and environmental factors that influence these patterns and to model the effects of climate and land use changes on these parameters.

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