A holistic approach for secure resilient terrestrial and coastal ecosystems"

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INTRODUCTION

- Apart from big carnivores(bears, cougars and wolves) also small raccoons, weasels, skunks and coyotes furthermore insects and Arachnids play a significant role in ecosystem.
- Relationship **between carnivores and plant genetic diversity is complex** and can vary depending on the specific ecosystem and species involved.
- However, overall, carnivores contribute to the ecological balance of terrestrial ecosystems, indirectly promoting plant genetic diversity through various ecological interactions and processes.

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RELATIONSHIP CARNIVORES & PLANT GENETIC RESOURCES

Conservation

- **Food Source:** Carnivores rely on a diverse range of prey species for food. When we preserve plant communities and maintain their genetic diversity, we ensure a stable and abundant food source for herbivorous animals. This, in turn, supports the populations of carnivores that depend on these herbivores for their survival. By protecting the plant species that carnivores prey upon, we indirectly preserve the carnivores themselves.

- **Habitat Preservation: Carnivores** require suitable habitats for hunting, reproducing, and seeking shelter. Plant communities provide essential habitat elements such as vegetation cover, nesting sites, and hiding places. By conserving plant communities, we maintain intact ecosystems that can support carnivore populations by providing the necessary resources and habitats they need to thrive.

RELATIONSHIP CARNIVORES & PLANT GENETIC RESOURCES

- **Trophic Interactions:** Carnivores are integral components of food webs and ecological interactions within ecosystems. They help regulate prey populations, preventing overgrazing and maintaining a balance in the ecosystem. This, in turn, promotes the persistence and diversity of plant communities. By safeguarding the carnivores, we contribute to the stability and health of the entire ecosystem, including the plant populations they interact with.

- **Conservation Hotspots: Many** areas with high plant diversity also serve as important habitats for carnivores. Biodiversity hotspots, which are regions with exceptionally high levels of plant diversity, often coincide with areas that support diverse carnivore communities. By prioritizing the conservation of these hotspots and their associated plant communities, we can protect the habitat and resources necessary for carnivores to survive and thrive.

BUT WHY PLANT GENETIC DIVERSITY IS IMPORTANT???

➢ Plant and Forest genetic resources (FGR) **are essential part of the adaptation and evolutionary processes of ecosystems.** Therefore, the conservation and appropriate use of FGR have a crucial importance for sustainable forest management in the light of climatic change.

➢A high level of variety of genetic variability safeguards the potential for ecosystems to regenerate, and facilitates their adaptation to environmental changes, as well as improving their resilience and productivity.

➢Marginal tree populations, constitute a source of valuable FGR for enhancing resilience of forests, due to their specific adaptive and evolutionary potential which may ultimately prevent species extinction under climate changes.

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Study examples for this important interaction

New Phytologist

Review

Tansley insight

A community genetics perspective: opportunities for the coming decade

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Contents

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Key words: community genetics, eco-evolutionary dynamics, foundation species, genes-to-ecosystems, herbivory, heritability, plant traits.

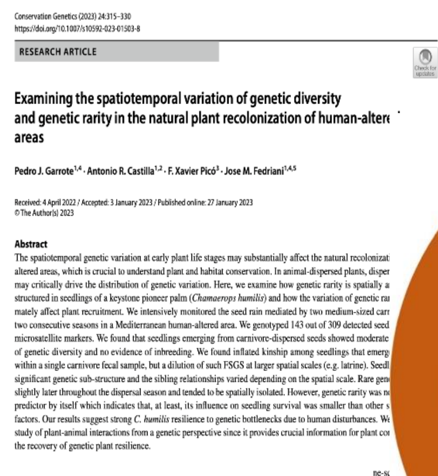
Summary

Community genetics was originally proposed as a novel approach to identifying link
genes and ecosystems, and merging ecological and evolutionary perspectives. The d
since the birth of community genetics have seen many empirical studies and comm
experiments, as well as the rise of eco-evolutionary dynamics research and a gene
ecology to incorporate intraspecific variation. So what have we learned from c
genetics? Can individual genes affect entire ecosystems? Are there interesting questi
be answered, or has community genetics run its course? This perspective makes a se
points about the general patterns that have emerged and calls attention to g
understanding to be addressed in the coming years.

I. Introduction

For decades, if not longer, ecologists have sought novel approaches or techniques that shed new light on the diversity of life around us, how it varies in space and time, or help predict which species are important or critical for their respective ecosystems. Proposed by Antonovics (1992) and featured more broadly in the ea
'community genetics' was one such approach, with
premise that genetic variation is a major driver of p
variation, which, in turn, has consequences that extend w
the population level (Whitham *et al.*, 2003). The
understanding the heritability and genetic architecture o
within species, we would ultimately have a clearer pict
links between the hierarchies of ecological organization, f
to ecosystems, and would be better able to place ecolo
evolutionary framework (Whitham *et al.*, 2006; Jo
Stinchcombe, 2007; Hughes *et al.*, 2008).

Gregory Crutsinger was a finalist for the 2015 *New Phytologist* Tansley Medal for excellence in plant science, which recognises an outstanding contribution to research in plant science by an individual in the early stages of their career; see the Editorial by Lennon & Dolan, **210**: 5.



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RESEARCH ARTICLE

Examining the spatiotemporal variation of genetic diversity and genetic rarity in the natural plant recolonization of human-altere areas

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Abstract

The spatiotemporal genetic variation at early plant life stages may substantially affect the natural recolonizati
altered areas, which is crucial to understand plant and habitat conservation. In animal-dispersed plants, disper
may critically drive the distribution of genetic variation. Here, we examine how genetic rarity is spatially a
structured in seedlings of a keystone pioneer palm (*Chamaerops humilis*) and how the variation of genetic ra
mately affect plant recruitment. We intensively monitored the seed rain mediated by two medium-sized carr
two consecutive seasons in a Mediterranean human-altered area. We genotyped 143 out of 309 detected seed
microsatellite markers. We found that seedlings emerging from carnivore-dispersed seeds showed moderate
of genetic diversity and no evidence of inbreeding. We found inflated kinship among seedlings that emerg
within a single carnivore fecal sample, but a dilution of such FSGS at larger spatial scales (e.g. latrine). Seedl
significant genetic sub-structure and the sibling relationships varied depending on the spatial scale. Rare gen
slightly later throughout the dispersal season and tended to be spatially isolated. However, genetic rarity was n
predictor by itself which indicates that, at least, its influence on seedling survival was smaller than other s
factors. Our results suggest strong *C. humilis* resilience to genetic bottlenecks due to human disturbances. We
study of plant-animal interactions from a genetic perspective since it provides crucial information for plant co
the recovery of genetic plant resilience.

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Taylor & Francis

PLANT-INSECT INTERACTIONS

OPEN ACCESS

Carnivorous plants and their biotic interactions

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ABSTRACT

Carnivorous plants reverse the order we expect in nature: here, animals do not feed on plants, but plants hunt and feed on animal prey, primarily insects, thereby enabling these plants to survive in nutrient-poor environments. In addition to this strategy, some carnivorous plants also form unique symbiotic relationships with animals other than insects to access nutrients. Other important interactions of carnivorous plants with insects, such as pollinators and herbivores, have received far less attention or have been largely neglected. This review describes and summarizes various ecologically relevant biotic interactions between carnivorous plants and other organisms reported in recent studies. In particular, our understanding on how carnivorous plants, for example, handle the pollinator–prey-conflict or interact with and respond to herbivores is still incomplete. Strategies and mechanisms on how carnivorous plants address these challenges are presented. Finally, future directions in carnivorous plant research are proposed.

ARTICLE HISTORY
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KEYWORDS
Plant carnivory; insects; prey capture; pollination; herbivory; defense; interactions

1. Introduction

Plants have adapted to utilize all available habitats, from tropical to arctic climates, arid to semi-arid zones, damp to waterlogged areas, and maximum sunshine to full shade. Therefore, as an adaptation to nutrient-poor environments, insectivory – or in a broader sense carnivory – may have evolved in some plants to compensate for shortages in soil composition (Juniper et al. 1989; Ellison and Adamec 2018a). Catching and digesting prey, mainly insects, by using specialized traps (Figure 1) is considered as an alternate mechanism for acquiring supplemental nutrients such as nitrogen, phosphorus, and potassium (Ellison 2006; Mithöfer 2011). Since all carnivorous plants can still fix carbon dioxide and absorb inorganic and organic nutrients from captured prey, they are mixotrophic. The 'carnivorous syndrome' refers to development by changes in anatomical structure, glandular structure, gene expression, and evolutionary characteristics (Pavlovič et al. 2007). About 810 of the 250,000 flowering plants species are carnivorous, mostly belonging to Nepenthales and Lamiales (Adamec et al. 2021). The carnivorous syndrome in plants has developed independently in the plant kingdom at least 11 times and can be found in 13 different plant families including a recently described new species (*Triantha occidentalis*; Tofieldiaceae) (Fleischmann et al. 2018; Lin et al. 2021). Therefore, carnivorous plants are a polyphyletic group with distinct features and prey-capturing abilities.

Charles Darwin was the first one who experimentally proved the fact of plant carnivory and laid the foundation for all subsequent research related to this topic in his book 'Insectivorous Plants' (Darwin 1875). Darwin described the traps structures in eight different plant genera (*Drosophyllum, Drosera, Dionaea, Aldrovanda, Roridula, Pinguicula, Utricularia, and Byblis*), all being able to catch insects or other prey. He further described the structure of sticky, hinged, and suction traps in detail, but also mentioned gliding traps. Darwin noted that pepsin-like enzymes directly digest the animal proteins (Darwin 1875; also in Hepburn 1922; Hepburn et al. 1927). Francis Darwin (1878) further concluded that the plant absorbs these nutrients, which contribute to the plant growth and development. In the last 25 years, molecular and all '–omics' approaches provided deep insight into the biology, physiology, and evolution of carnivorous plants. In particular, intensive work on Darwin's 'most wonderful plant of the world,' the Venus flytrap (*Dionaea muscipula*), gained fascinating insights into the molecular physiology and origin of plant carnivory and contributed significantly to our understanding of carnivorous syndrome in this particular plant and also in general (for review, see Hedrich and Fukushima 2021). In addition, comprehensive publications recently covered the systematics, evolution, and (eco)physiology of carnivorous plants (Ellison and Adamec 2018a; Adamec et al. 2021). In this article, I provide an overview on the various biotic interactions of carnivorous plants (Figure 2). Besides summarizing their interactions with prey and addressing the related question whether carnivorous plants are predators, I focus, in particular, on the often neglected interactions with pollinators and herbivores, emphasizing the signals involved in attraction and defense responses.

2. What makes a carnivorous plant?

There are several definitions for the term 'carnivory' in the plant kingdom. The basic definition implies that a carnivorous plant has the ability to absorb products of prey decomposition. This is done either directly through the leaves or through the roots, and increases fitness and seed production at the same time (Chase et al. 2009). Accordingly, all plants can be carnivorous to some degree, but only those that can

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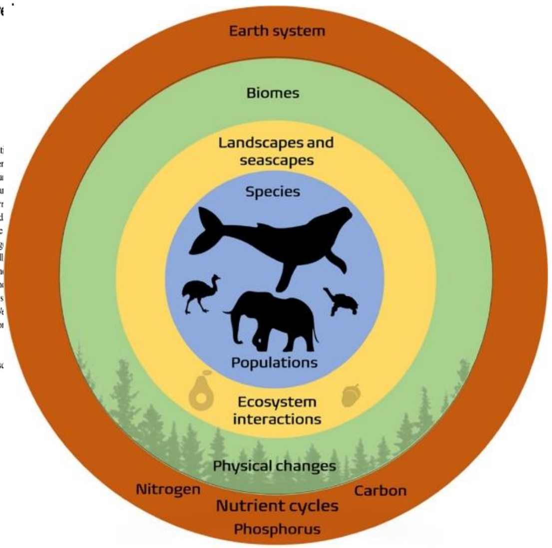
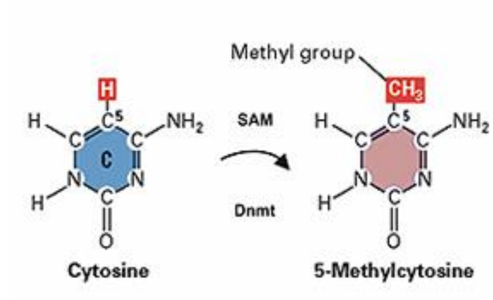


Trends in Ecology & Evolution

DOES ALSO EPIGENETICS CONTRIBUTE????



Epigenetics is defined as mechanisms that regulate gene expression without base sequence alteration.

Main epigenetic mechanisms:

➢DNA methylation (addition of a CH3 in a cytosine)

➢Modification of histones (phosphorylation, acetylation)

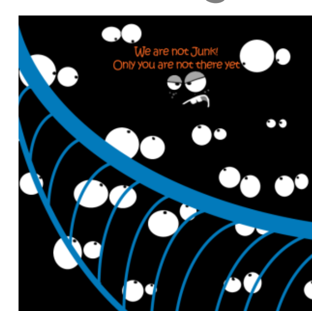
➢mRNAs

DOES ALSO EPIGENETICS CONTRIBUTE????

- DNA methylation could be involved in short-term responses to environmental changes.

- No study has addressed the question whether and how epigenetic variation influences adaptive traits in marginal populations. Will epigenome and genome x epigenome interactions contribute to sustain and conserve important marginal forest tree populations? Is there is a relationship between fluctuating asymmetry and stress?

- Conclusions that will be produced from the associations of genotype, epi-genotype and phenotype will be of paramount importance for the protection and conservation of marginal forest tree populations.



NATURA 2000

- **Natura 2000** is a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right conserve. Natura sites all over countries halt high biodiversity of flora and fauna “in situ” while “ex situ” conservation strategies have little been applied.

- Natura sites are covered from forest lands and various ecotypes. Carnivores populations resilience in Natura sites are strictly depending on their forest natural reservoir where they live and reproduce. In order to reassure and protect carnivore’s long term population survival primary conservation of their natural habitats must be secured in the face on ongoing climatic changes.

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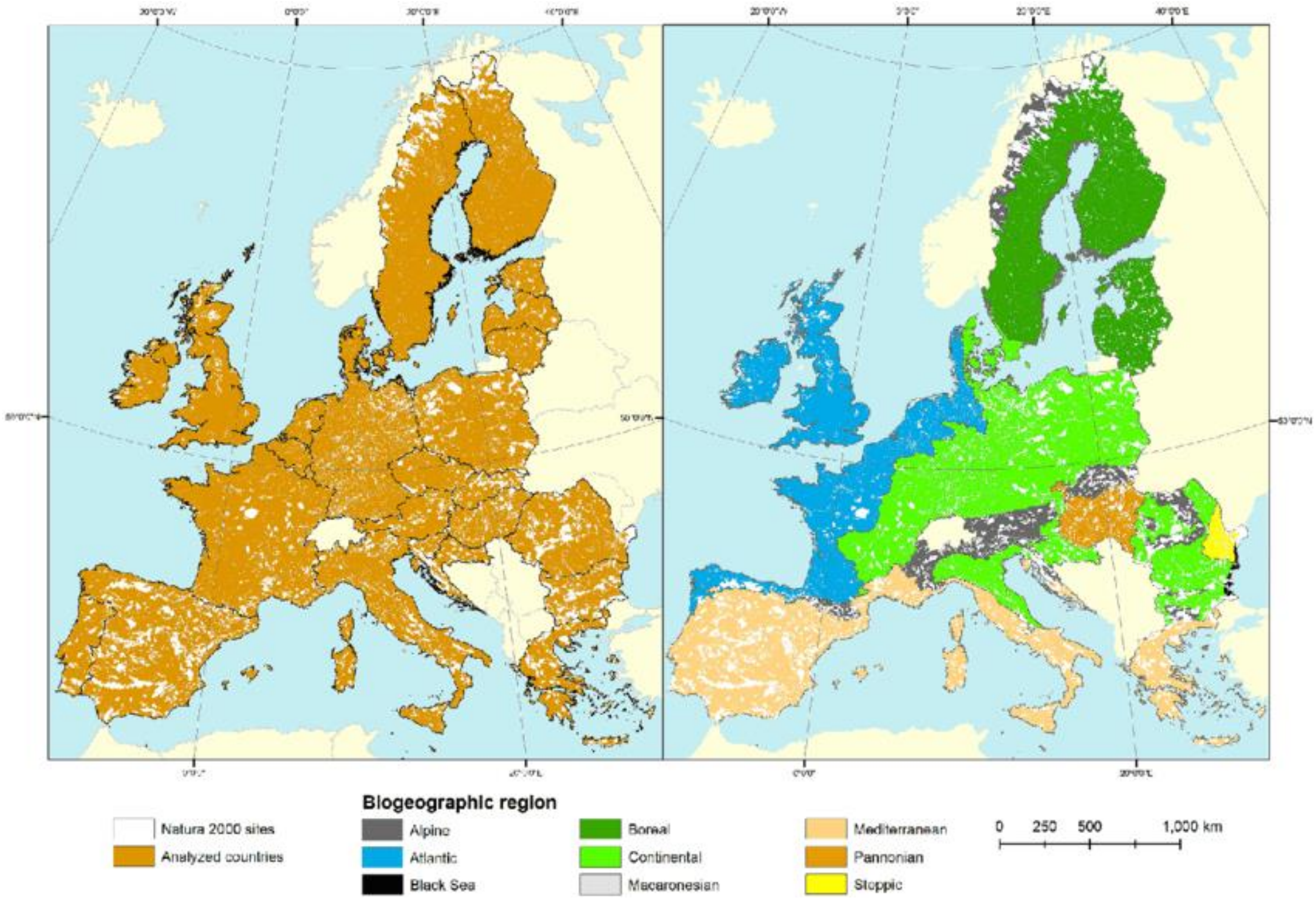
NATURA 2000 NETWORK IN EUROPE



Adopted from: 20 years of landscape dynamics within the world's largest multinational network of protected areas
December 2020 Journal of Environmental Management 280
DOI: 10.1016/j.jenvman.2020.111712

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Implementation??? HOW???

- Conserving genetic diversity is the key element for conserving biodiversity carnivores population resilience and sustainability.

- Natura 's sites conserve high biodiversity of flora and fauna *in situ* while *ex situ* conservation strategies have never been applied.

- Combining study of genetic, epigenetic physiological and biodiversity indicators will ensure future protection, conservation and resilience of those important forest ecosystems.

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Proposed sites for example in Greece:

The project can focus on 3 Natura sites in Greece:

1. **Mt Parnonas** halt the unique forest of *Juniperus drupacea*, which is an endangered species while harbors also populations of golden jackal (Canis aureus).
2. **Mt Oiti** harbors 1.149 species and sub-species of plants but it is estimated that there are more than 1.250, that means almost the 1/5 of the Greek flora. In Oiti one can meet the wolf *(Canis lupus)*, included in Directive 92/43/EEC.
3. **Mt Parnitha** harbors also 1146 taxa and maintain populations of *Abies cephalonica*, *Juniperus oxycedrus*, *Platanus orientalis* etc. In Mt Parnitha there are 39 mammals from which 25 are in the IUCN Red list of threatened species and 35 in Bern Convention. The red fox, *(Vulpes vulpes)* forms populations in the mountain.

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Secure sustainability of forest ecosystems through the study of genetic and epigenetic parameters in order to enhance and protect terrestrial ecosystems of carnivores.

Compliance with EUSAIR-Pillar 3 flagships

- This project idea fully complies with the priority action Topic 3.2 Transnational terrestrial habitats and biodiversity.
- Specifically, the project will improve the resilience of large carnivores populations in the face of environmental threats and risks.

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In conclusion!!!

Carnivores are animals that primarily feed on other animals. They play an essential role in terrestrial ecosystems, not only by controlling prey populations but also by influencing plant genetic diversity indirectly:

- **Trophic Cascade:** Carnivores **can trigger a trophic cascade**, which is a chain of effects that starts at the top of the food chain and trickles down to lower trophic levels.

- **Seed Dispersal:** Many carnivores contribute to seed dispersal by consuming herbivorous animals or their carrion. They often travel over large areas, **carrying seeds in their digestive systems** or attached to their fur. This dispersal mechanism aids in gene flow and genetic exchange among plant populations, enhancing genetic diversity across different habitats.

In conclusion!!!

- **Pollination:** Some carnivores, such as bats, birds, and certain insects, act **as pollinators for various plant species**. Through their foraging behavior, they transfer pollen between flowers, facilitating fertilization and subsequent seed production. Pollination by carnivores ensures gene flow among plant populations, reducing the risk of inbreeding and maintaining genetic diversity.

- **Habitat Modification**: Certain carnivores, like burrowing mammals or large predators, **can modify the physical structure of their habitats**. For example, by digging burrows, they create microhabitats that offer unique conditions for plant growth and colonization. This habitat heterogeneity promotes the establishment of diverse plant species and increases genetic diversity within a given area.

- **Nutrient Cycling**: Carnivores play a role in nutrient cycling within ecosystems. When they consume prey, the nutrients from the prey's tissues are transferred to the carnivores. **Through defecation and decomposition of carcasses, carnivores release these nutrients back into the environment.** Adequate nutrient availability supports plant growth and enhances genetic diversity by providing essential resources for reproduction and adaptation.

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Thank you for your attention!