11th clonal plant workshop

Clone 2015 Třeboň

ABSTRACTS

4–7 August 2015, Třeboň, Czech Republic

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CLONE 2015, TŘEBOŇ, CZECH REPUBLIC
11TH CLONAL PLANT WORKSHOP

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Institute of Botany of the Czech Academy of Sciences

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TALKS

ACCOUNTING FOR PHYLOGENY WHEN ASSESSING THE FUNCTIONS OF CLONAL TRAITS

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Plants have evolved a tremendous diversity of organs and structures that enable clonal growth. Such clonal traits are among the key factors that determine differences among plant's ecological strategies. They thus have the potential to give insights on plant species distribution patterns, species coexistence theories and vegetation effects on ecosystem properties. Because plants and their traits are the result of evolutionary processes, the need to account for phylogenetic relationships among species has been advocated in the framework of phylogenetic and functional comparative methods. Moreover phylogeny even sometimes entirely replaces trait information. However, there is considerable uncertainty about when and how phylogenetic information is actually needed to answer questions about the ecology of traits, communities, and ecosystems. With a focus on clonal traits, we identify different basic questions in functional trait-based ecology and discuss potential approaches to incorporate phylogenetic information to tackle these questions, and their usefulness. We then review key examples in the literature combining phylogenetic information and clonal traits. Further, we demonstrate a new method for community ecology to study the functional diversity of clonal traits after partialling out the effect of phylogeny and compare it with other approaches combining traits and phylogeny.

CLONAL PLANTS AND FACILITATION RESEARCH: BRIDGING THE GAP

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Over the last 20 years there has been a substantial increase in interest in plant facilitation – beneficial effects between physiologically isolated neighbouring plants. Beneficial plant-plant interactions are nothing new for researchers working on clonal plants. But despite the obvious links between these two research fields, relatively little work has explicitly considered the links between plant clonality and "classic" facilitation, even though both phenomena are considered more common in some kinds of environment (e.g. arctic and alpine systems). This presentation will define more clearly where areas of overlap between these research fields might lay, and ideas for future research activities that could lead to their greater integration.

ECOLOGICAL EFFECTS OF AN INVASIVE CLONAL PLANT, *WEDELIA TRILOBATA*, AND ITS INVASION MECHANISMS

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The invasive plant *Wedelia trilobata*, one of the 100 Worst Invasive Species in the World, is a representative clonal creeping herb with strong stolons. It reproduces with its rapid clonal growth, resulting in dense population canopy in the field and huge ecological effects on the structure and function of ecosystems in China. What are the successful invasion mechanisms of *W. trilobata*? Based on the relatively high proportion of ent-kaurane diterpenes, which are gibberellin (GA) precursors in *W. trilobata*, and it grows rapidly in invaded habitats, we found that the endogenous GA in the ramets can facilitate its fast colonization and dispersal in invaded habitats, and GA facilitates the growth of *W. trilobata* faster than that of its native congener W. chinensis. Our results also showed that the clonal growth characteristics of *W. trilobata* showed significant differences among the invaded sites on Hainan Island, China, suggesting that the species was able to adapt to different environments. The mean phenotypic plasticity index of *W. trilobata* was higher than that of other invasive plant species. The molecular variance in the genetic diversity of the population showed significant differences among the sites. The responses of plants grown from different sites to light treatment varied. Arbuscular mycorrhizal fungi (AMF) also promoted the phenotypic plasticity and allometry of *W. trilobata*. The rapid growth of *W. trilobata* caused dense litter layer and lack of light under its populations, which might be two major factors responsible for the low numbers of *W. trilobata* seedlings found in the field. And litter of *W. trilobata* also may contribute to the species' own growth and inhibit both invasive and non-invasive competitors' growth, thereby facilitating the invasion of *W. trilobata*.

EFFECT OF NUTRIENT AVAILABILITY ON RECOVERY ABILITY OF *ALTERNANTHERA PHILOXEROIDES* AFTER ATTACK OF MEALYBUGS

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The successful invasion of non-native plants is often influenced by the native insect herbivory. To investigate the plant-insect interaction may help us to better understand the underlying invasion mechanism of non-native plants. We conducted a series of control experiments to investigate the recovery ability of a typical wetland invasive plant *Alternanthera philoxeroides* after the attack of mealybugs. Interestingly, the recovery ability of *A. philoxeroides* after the attack was closely related to the local nutrient availability. *A. philoxeroides* plants in the high-nutrient condition could recover more rapidly (e.g., the higher relative growth rate of leaf mass and ramets) and accumulate more biomass than that in the low-nutrient condition. These plant responses may potentially increase the invasiveness of non-native plants in the introduced, fertile anthropogenic regions.

EPIGENETICS: A POTENTIAL MECHANISM FOR CLONAL PLANT SUCCESS

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Clonality in plants is widespread and includes species that span temporally and spatially heterogeneous environments. Yet, theory predicts that clonally reproducing plants evolve at slower rates, risk accumulating more mutations than sexuals, and potentially lack the benefits of DNA repair mechanisms afforded by meiosis. Does the apparent success of clonal plants contradict the severe costs of clonal reproduction suggested by theory? Epigenetics may confer ecological advantages to clonal plants that could outweigh these evolutionary costs. Relying to various degrees on vegetative reproduction, the capacity to conserve or reverse gene regulation changes over cell divisions has clear potential for optimization of plasticity and acclimation in response to environmental variation encountered. Clonal plants may be one of the best examples of organisms taking advantage of epigenetic acclimation as an alternative to the slower mechanisms of adaptation through natural selection. In this context, we report on our results investigating epigenetic variation in *Phragmites* a facultatively clonal plant in an environmentally variable field based study. Epigenetic gene regulation, a form of plasticity transferable across cell divisions and potentially sexual generations, confers dynamic and stable responses to environmental heterogeneity, characteristics that may be critical for successful plant invasions. *Phragmites* provides an exceptional opportunity for the comparison of invasive and non-invasive lineages within the same species and across a range of environmental conditions. Results found large and significant differences ($p < 0.001$) in epigenome between lineages (native vs. invasive) and within genotypes (clonal ramets) but smaller difference between genotypes within lineages (genetically distinct genotypes). This suggests that the native and invasive lineages have distinct epigenomes, most epigenetic variation within a lineage is independent of genetic variation, and clonal ramets have distinct epigenomes in response to local site variation.

ECOLOGY OF ASPEN IN COLORADO FRONT RANGE, USA

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In the Southern Rocky Mountain region, species richness, nutrient cycling and herbaceous biomass are generally higher under aspen (*Populus tremuloides*) than in conifer-dominated habitats, justifying the interest in protecting these communities. It is unclear whether aspen are increasing, decreasing, or persistent in Colorado, and the recent mountain pine beetle epidemic has raised more questions regarding aspen's future. We present here two studies that assess aspen dynamics and physiological response to changes in the mountains. First, we relocated and resampled 89 plots containing aspen first sampled by Robert Peet during 1972-1973. We hypothesized that aspen have decreased in density and basal area over the past 40 years due to reduced fire frequency, increased herbivory and increasingly drier weather. Second, we examined the release of aspen following a bark beetle epidemic and assumed aspen would focus their carbon resources toward stem growth rather than sucker reproduction. Our data only partially support our hypothesis of aspen decline. Although there has been an extensive and conspicuous decrease in aspen density on the landscape scale, most of this decline occurred in 11 plots that were part of Peet's aspen-dominated *Populus tremuloides* series, accounting for 55.09%, 94.91%, and 94.01% of total aspen decline in herb, shrub, and tree stratum, respectively. Moreover, basal area of aspen in this vegetation type declined by 57%. The considerable declines in aspen stem density in all strata of this vegetation type, coupled with increases in *Picea engelmannii*, *Pinus contorta*, and *Pseudotsuga mensiezii*, indicate that aspen is being replaced by other species. Aspen release following bark beetle matched our hypothesis; little suckering and clear stem diameter growth. Together, results suggest aspen is maintaining itself in the Front Range even though sexual reproduction is absent, and, as many studies have shown, aspen is dependent on disturbance.

COMMUNITY CONSEQUENCES OF BODY SIZE IN CLONAL PLANTS

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Body size is one of the most fundamental organismal traits with important consequences for ecological interactions. In plants, large size is often assumed to be associated with competitive ability and therefore ability to invade. However, large size also has associated costs, including reduced reproductive efficiency, and therefore the population and community ecological consequences of interactions among individuals with different maximum potential size may be quite different from that expected from individual-level interactions. We used a community-ecosystem model for clonal plants called MONDRIAN to investigate the consequences of differences in potential size for competitive success along a nitrogen gradient, testing three hypotheses: 1) Invader success and competitive ability is a unimodal function of maximum plant size, such that plants smaller OR larger than an optimal plant size are less successful. 2) Optimum maximum potential mass increases with nutrient supply even in the absence of interspecific competition. 3) This optimum further increases under interspecific competition, especially, but not only, when competing for light. Simulations using parameterizations for successful wetland invasive plants are consistent with all three predictions, suggesting that general statements that bigger plants are better competitors or better invaders will not be generally true, although they will hold for limited comparisons. Importantly, size-symmetric competition for nutrients only and competition for nutrients plus size-asymmetric competition for light have similar qualitative results along the nitrogen gradient, although the competitive advantage of large size at high nitrogen is quantitatively bigger when competition is for light as well as nutrients. These results highlight the danger of using results of short-term competition experiments to extrapolate to long-term population and community dynamics.

HOW DOES CLONALITY CONTRIBUTE TO COMMUNITY RESPONSES TO FERTILIZATION?

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Clonal plants have long been implicated in declines of species richness and species evenness in fertilized grasslands and it has been hypothesized that the observed decline in species diversity in relation to productivity may be related to the presence of clonal species in the community. Although "clonality" per se may not be predictive of species loss in response to fertilization, the type of clonal growth in combination other traits, particularly height, appears to be predictive of both species and community responses to fertilization. Data from several long-term studies in grasslands in SW Michigan, USA, will be presented to examine how traits of species in a community can determine the magnitude of species loss due to fertilization.

TO FIGHT OR NOT TO FIGHT: DECISION MAKING IN PLANTS UNDER COMPETITION

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Plants can respond to light competition by either confronting their neighbours via vertical stem elongation, or by tolerating light deficiency through morphological and physiological adjustments. Some plants, particularly clonal species, can also avoid competition by growing laterally away from their neighbours. Previous studies have mainly examined different evolutionary backgrounds that might select for either one of these strategies, depending on the height and density of neighbours. However, such factors can vary even within the same environment and plants are thus expected to be able to switch between responses according to prevailing competitive conditions. In this study we examined this hypothesis with the clonal plant Potentilla reptans using grids of plastic filters, which simulated vegetative shade in four competitive environments of varying densities and heights. The greatest confrontational behaviour was exhibited under competition with dense but short neighbours, which could be easily overtopped vertically. In contrast, the greatest tolerance behaviour was exhibited under competition with dense and tall neighbours that had low prospects of being outgrown. These results therefore provide first support to the idea that plants can shift between different plastic responses according to local competition settings.

CLONAL TRAITS MEDIATE PLANT SPECIES RESPONSE TO CLIMATE CHANGE: EVIDENCE FROM A WHOLE-COMMUNITY TURF TRANSPLANT EXPERIMENT IN SOUTHERN NORWAY

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Ecologists have gradually settled on a "common core" of plant species traits that are easily measured and putatively represent meaningful axes of variation in plant strategy. These traits focus on plant characteristics relating to individuals or ramets – e.g. leaves, stems, flowers, and seeds – and ignore traits relating to clonality – e.g. clonal architecture, rate of lateral spread, persistence of ramet connectivity. The lack of attention to clonal traits is unfortunate as clonality is extremely common in plant communities and may be an important predictor of species performance following environmental perturbation. Here, we use an ongoing turf transplant experiment in southern Norway to investigate the influence of clonal traits on community dynamics following rapid climate change, both in comparison to and in conjunction with commonly used individual-level plant traits and data on seed rain. Intact alpine and subalpine turfs were transplanted to warmer, wetter or warmer and wetter climates. We compared observed changes in the community composition of transplanted turfs to neutral expectations based on model simulations to understand the roles of ramet-level and clonal traits in community response to climate change. Our consideration of clonal growth led to improved predictions of community dynamics in both control turfs and transplanted turfs. Community composition in adjacent cells was a better predictor of immigrant identity than seed rain or overall site community composition. In addition, specific types of clonal growth architecture showed differential rates of per capita immigration success following transplantation to new climates, illustrating the influence clonal traits can have on short term community dynamics. We hypothesize a colonization-competition trade-off in clonal growth strategy, wherein species capable of rapid vegetative spread arrive more readily to high quality sites but are ultimately displaced by "clumping" species which are better competitors for resources once established. Our results illustrate the potential importance of including clonal plant ecology into models of community response to climate change.

THE INVASION RACE: SPEED AND PERSISTENCE IN CLONAL EXPANSION

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How to explore the favourable patches in a heterogeneous habitat sensing only its local quality? We studied this question by computer simulations with a focus on clonal growth. The habitat consisted of good and bad patches. Only good patches provided sufficient resource for the survival and further growth of the plant. Entering into a bad region was, thus, costly, but had two possible advantages. First, it could enable the plant to reach further good patches; second, it could speed up colonization by shortcuts. Whether these benefits outweighed the costs depended on the pattern of good patches. The plant could follow an Entering, Avoiding, or probabilistic Mixed strategy. The strategies differed in how often the resource was translocated from ramets in good sites into ramets in bad sites (e). In the Entering plant, e was maximal: the exploration of new sites proceeded even at the expense of survival in good sites that have already been found. In the Avoiding plant, e was minimal: the plant never entered into bad sites. We compared these strategies in various environments, using two spatially explicit models of ramet dynamics. In model 1, we studied the equilibrium occupancy of space. A genet was considered more successful than its competitor if it exploited a larger good area. In model 2, we observed the time-dependence of occupation, assuming that passing through a bad area slowed down growth. We considered a genet more successful if it could reach a larger good area sooner than its competitor. The results of model 1 indicate that a Mixed strategy can occupy more good space than any of the pure strategies. Between two Mixed strategies, always the one with a lower e was more efficient. But model 2 showed that those strategies that filled space more successfully were less successful in terms of speed. In conclusion, when a habitat with a given set of competitors favours high speed of spreading, then it selects for risk seeking (higher e), otherwise, for risk aversion.

DEFINING PHYLOGENY AND CLONAL STRUCTURE OF A RARE SHRUB, *GREVILLEA INFECUNDA* (PROTEACEAE), USING GENETIC MARKERS

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Grevillea infecunda is a rare, woody shrub described in 1986 from a small coastal area in southern Australia. The species relies on clonal reproduction from rhizomes because pollen is not viable. *G. infecunda* had previously been assigned as a sterile variant to the more common, but not sympatric species, *G. aquifolium*. However, phylogenetic analysis using nuclear and chloroplast sequences obtained by Ion Torrent NextGen sequencing has distinguished it from G. aquifolium increasing its conservation value as a distinct genetic entity. The species occurs in 11 populations that have been fragmented in recent decades and are subject to ongoing damage from recreational activities, mining and urbanisation. Nuclear microsatellites and chloroplast sequences obtained were used to identify maternal lineages and individual clones which were found to vary greatly in size across the species' range. Fire is a natural occurrence in the heathland habitat of *G. infecunda*. The species can re-sprout after fire but the potential for wildfires to destroy populations is a high risk factor. Samples taken before and after fire confirmed that new plants were ramets of genets sampled prior to burning. Mapping of clones will allow fuel reduction burns to be designed so that only part of a clone is burnt at any one time and to assess other risk factors on a clone by clone basis.

STRESS INDUCED MEMORY IN CLONAL OFFSPRING OF *TRIFOLIUM REPENS*

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An increasing body of evidence shows that parents can pass information about their environment to the offspring generation. This phenomenon that is usually called transgenerational effects (TE) can be enabled by environmentally induced epigenetic change, however solid evidence is still lacking. Transgenerational effects can obviously play important role in the ecology and evolution of plants because they can alter plants interactions with environment. Whereas TE are relatively well documented for sexual generations, almost nothing is known about the role of TE in clonal generations. In our study we tested the role of four stresses (drought, salt, shading and heavy metal) on induction of TE in clonal offspring of five genotypes of the common clonal species *Trifolium repens*. By use of methylation-sensitive AFLP technique we also measured stress-induced DNA methylation changes and determined its stability among several offspring cohorts. Our results show that clonal offspring (ramets) can remember the stress that experienced parental clone even after disintegration from the clone. The stress induced memory had strong effect on the growth of several offspring cohorts and was likely driven also by epigenetic variation. Based on our results we suggest that the ability to remember parental conditions can be important aspect of clonal strategy because it can provide important information from the past that can be used for decision making about the further growth.

FRAGMENTATION OF THE INVASIVE, CLONAL PLANT *ALTERNANTHERA PHILOXEROIDES* DECREASES GROWTH BUT NOT COMPETITIVE EFFECT ON WETLAND PLANTS

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Clonal integration and clonal fragmentation are potentially competing advantages of clonal growth, especially in aquatic plants. Physiological integration between connected ramets can increase their combined growth, but detachment of apical sets of ramets can spread clones widely. We hypothesized that one trade-off between integration and fragmentation on clonal aquatic plants is that fragmentation reduces the growth and competitive effect of clones on other plant species. We also hypothesized that, in amphibious clonal plants, competitive effects on other, primarily aquatic species would be greater in terrestrial than in aquatic habitats and that reduction of competitive effect due to fragmentation would likewise be greater in terrestrial than in aquatic habitats. To test these hypotheses, we grew four common species from wetlands in China under flooded or unflooded conditions with or without fragmented or unfragmented plants of *Alternanthera philoxeroides*, a widespread, introduced, amphibious, clonal plant in China. Presence of *A. philoxeroides* decreased the growth of the other species, and competitive effect was greater when plants were not flooded than when they were. Fragmentation of *A. philoxeroides* did not reduce its competitive effect or production of new ramets or stems, though it did reduce its total accumulation of mass. Results suggest that clonal plants may mitigate trade-offs between the potential ecological advantages of integration and fragmentation by maintaining vegetative reproduction even when total growth is reduced.

THE RESPONSES OF BELOWGROUND BUD BANK AND ITS REGENERATIVE CONTRIBUTION TO GRAZING AND ENVIRONMENTAL FACTORS IN NATURAL GRASSLAND OF INNER MONGOLIA, CHINA

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Bud bank plays important roles in plant population maintenance and regeneration, as well as community composition and dynamics. Understanding the responses of bud bank size, composition and regenerative contribution to disturbance and climatic change is critical for implementing a sustainable grassland management and biodiversity conservation on the natural grassland. The responses of bud bank size and composition to grazing, bud bank size and composition along the climatic gradient, and the relative contribution of different bud bank types to aboveground vegetation are the key scientific questions in bud bank research. By investigating the responses of bud bank and its regenerative contribution to grazing and the changes of bud bank along a climatic gradient on the natural grassland of northern China, this study aimed to explore the ecological functions of different bud bank types responding to disturbances and climate changes. Our results showed that 1) grazing regimes had significant influences on belowground bud bank size, while total bud density did not change significantly with increasing grazing intensity; 2) compared with continuous grazing, grassland enclosure suppressed the whole regenerative contribution of belowground bud bank; 3) the relative contribution of different bud bank types changed along the grassland degradation gradient; 4) total bud density first increased and then decreased significantly along the mean annual precipitation gradient, while it decreased significantly along the mean annual temperature gradient; 5) the sensitivities of different bud bank types to climatic changes were: rhizome buds > tiller buds > root-derived buds > bulb buds. This study presents new insights into the ecological function of bud banks and includes some new information on the responses of bud banks to different disturbance intensities and environmental stress levels.

THE BENEFITS FROM CLONAL PROPAGATION: IMPACT OF IMPORTED ASSIMILATES FROM CONNECTED RAMETS

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To benefit from the expansion in space clonal plant must at first invest some of its resources to production of clonal offspring. We used an experiment where we could distinguish both the difference in investment to clonal growth and the benefit from clonal growth in plants which grow either in poor or fertile soils. In less fertile conditions the investment to clonal growth could be more costly, however also the benefits could be larger if a plant can attain resources from a larger area. Thus, the growth form of plants could also influence the costs and benefits from clonal growth. We established an experiment where half of the plants of *Elymus repens* (long rhizomes) and *Alopecurus pratensis* (short rhizomes) were planted through the black woven agrotextile laid into either fertile or unfertile soil. The textile prevents plants growing under it to reach sunlight. Another half of the plants were allowed to grow freely. We harvested all the plants when their seeds were matured. The size of plants and number of clonal offspring was primarily affected by soil fertility and covering only impacted growth of *E. repens*. However, covering increased by almost 50% the seed production of *A. pratensis*, whereas the total rhizome length per genet of *E. repens* was significantly longer in poor soil and covered conditions. We observed a constant investment into clonal offspring in *E. repens*, but decreasing investment in poor soil condition in *A. pratensis*. *Elymus repens* benefitted from clonal growth only in fertile conditions where plants grew bigger while *A. pratensis* showed no signs of direct benefits. However, the reaction of plants to the worst conditions (covering + poor soil) is in accordance with their growth form – *E. repens* increases the length of its rhizomes while *A. pratensis* increases the seed production. Thus, when evaluating the relationships between clonal growth and environmental conditions, the growth form of plants must be given serious consideration.

SURVIVAL DEPENDS ON RESOURCE SHARING: EVIDENCES FROM THE EPIPHYTES IN A MONTANE MOIST FOREST, SW CHINA

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Forest canopy-dwelling plants (i.e. epiphytes) which have no vascular connection to the ground or to their host plants (i.e. phorophytes) play a vital role in biodiversity conservation, floristic composition, water and nutrient cycling in tropical and subtropical forests. Almost all non-vascular epiphytes and many vascular epiphytes are capable of clonal growth, but little is known about the role of clonal integration of epiphytes in surviving harsh forest canopy. To discuss the roles of resource sharing (i.e. clonal integration) in forest canopy adaptation, two field experiments (single-ramet and plot experiments) were conducted on two most dominant vascular epiphytes, *Polypodiodes subamoena* and *Lepisorus scolopendrium*, in a subtropical montane moist forest in Southwest China in wet season. The results showed that there were significant negative effects of rhizome severing on survival of ramets in both experiments, on total and belowground biomass in both experiments, and on maximum quantity yield of PS II (Fv/Fm) in single-ramet experiment, and that such effects did not depend on species (no interaction effects). Therefore, resource sharing (i.e. clonal integration) increased the survival and growth of epiphytes in wet season, the effects of resource sharing on the performance of epiphytes did not depend on species with different morphological traits.

DYNAMIC GROWTH ADAPTATION OF A CLONAL RIPARIAN PLANT TO WATER LEVEL FLUCTUATION

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Most riparian plants are clonal plants. These plants can well tolerate stress of water level fluctuation, a common phenomenon at riparian regions. However, the adaptation mechanisms of these plants to water fluctuation are still not well understood. In this study, a typical riparian wetland clonal plant *Alternantera philoxeroides* was subjected to a 40-day water fluctuation with low and high frequencies: two and four times. For the low frequency, the first fluctuation was plants flooded during the first 10 days, and then re-emerged during the next 10 days; for the high frequency, the first fluctuation was flooded for 5 days and re-emerged for the next 5 days. We specifically tested the following two hypotheses: (1) riparian plants may have a dynamic adaptation with increased fluctuation times; if yes, (2) high frequency fluctuation may have stronger positive effects on plant growth than low frequency fluctuation. The results showed that the effects of flooding on plant growth decreased for both low and high frequency treatments with the increased fluctuation times. The re-exposure did not affect recovery growth of plants for the low frequency treatment, but decreased it at the end of the high frequency treatment. Compared with the high frequency treatment, the low frequency treatment significantly decreased plant growth during the flooding, but increased plant recovery growth during the re-emergence. The results suggest that increased frequency can increase plant adaptation to water fluctuation. The low frequency can stimulate a higher recovery growth of riparian plants than the high frequency.

VARIETY OF BAMBOO FLOWERING PATTERNS, WITH SPECIAL REFERENCE TO THE SIGNIFICANCE TO THE SPORADIC SMALL SCALE FLOWERING

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Bamboos are well known to have semelparous peculiar life history. After a long period of vigorous rhizomatous clonal growth, they often show synchronized death after flowering in a wide range. Flowered areas were reported about several thousand square km for *Melocanna baccifera* in India (Shibata 2009), several hundred km^2 for *Guadua* spp in Amazon (de Carvalho et al.2013), about ten km^2 for *Sasa kurilensis* in Japan (Makita 1995), and so on. Although only these episodic extensive flowering events are attracted attention, bamboos, in actuality, represent various flowering behaviour. In this talk, I focus on the sporadic small scale flowering to consider whether to have the various flowering patterns is meaningful for bamboo life history. In Japan, dwarf bamboos, *Sasa* spp. are distributed widely in cool temperate and boreal zones. Though they flower gregariously in a long interval, over 100 years, the small scale flowering are also often observed in a scale of a hundred to several thousand $m^{2.}$ To clarify the significance of small scale flowering, clonal structure, seed set, and self-pollination rate were observed in and around 24 flowering patches for *Sasa* spp. (Mizuki et al. 2014). In the case of gregarious flowering, many genets synchronize to flower (Matsuo et al. 2014), multiple genets flowering were only 1/3 of the sporadic flowering patches. Many of the flowered genets had un-flowered ramets around the flowering patches, which suggests these flowered genets may be iteroparous. Selfish rate was much higher and seed set was lower than those in mass flowering. In some cases, however, seed production was made and seedling population was established even in a single genet flowering. In a sense, semelparous life history is a dangerous strategy, because the success of regeneration depends on only one opportunity. Small scale flowerings may play a role as the insurance. Based on these findings, I will discuss the significance of scattered flowering on the evolution of bamboo flowering habits.

Mizuki I et al. 2014, Plos ONE 9:e105051, Matsuo A et al. 2014 Annals of Botany 114:1035-1041

THE EVOLUTION OF INTRASPECIFIC VARIATION OF REPRODUCTIVE SYSTEM IN *VIOLA BREVISTIPULATA*

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The plants in the genus *Viola* can normally produce both chasmogamous (CH) and cleistogamous (CL) flowers within single plant. However, our previous study (Hayamizu et al., 2014) reported that intraspecific variation in reproductive system. That is, some populations produce seeds via both CH and CL flowers (CH/CL type). The other populations produce only CH flowers with very low seed reproduction and reproduce mainly by clonal growth of root system (CH/clonal type). In the present study, we surveyed geographical distribution of CH/CL and CH/clonal populations across the distribution of the species. Second, we analysed phylogenetic relationships of CH/CL and CH/clonal types using both of nuclear DNA (598bp of ITS locus) and chloroplast DNA (1,652bp concatenated sequences of 4 region) markers. Field survey of 30 populations revealed that all of the populations investigated were distinguished as either CH/CL or CH/clonal types. The geographical distribution of CH/CL type populations were restricted in the range of the Pacific Ocean side. The populations of CH/clonal type were distributed mainly in the range of Japan Sea side and represented wide distribution range by comparison with CH/CL type populations. The phylogenetic analyses by using nDNA and cpDNA showed that *V. brevistipulata* constructed a clade that is clearly distinguished from closely related species (*V. orientalis*). In addition, CH/CL and CH/clonal type populations were not shared with the same haplotypes except for one population. Haplotype diversity was higher in CH/clonal type than CH/CL type even populations of CH/clonal type were maintained mainly by clonal growth. Consequently, the populations of *V. brevistipulata* with two different reproductive systems seem to have experienced different evolutionary history.

DOES HIGH GENETIC DIVERSITY PROMOTE LOW FREQUENCY IN VIRUS INFECTION IN CLONAL PLANT *DIOSCOREA JAPONICA*?

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The cost of sexual reproduction is thought to be taken more than two times as high as that of clonal reproduction. However, many plants possess clonal and sexual reproductive habits. The genetic variation via sexual reproduction would prevent from the parasite infection. In these host-parasite interactions, negative frequency-dependent selection was preferred evolutionally, which was often called for "Red Queen Hypothesis". The aim of our study was to explore the relationship between genetic diversity of host plants and virus infection rate in the field. *Dioscorea japonica* (Dioscoreaceae) is the perennial clonal herb which produces bulbils on its leaf axils. Bulbils were produced from both sexes and seeds were produced from female ramets because of its dioecy. The main infected viruses of the species are Japanese yam necrotic mosaic virus (JYMV) and Chinese yam necrotic mosaic virus (CYNMV). In the farm, when the plants infected by these viruses, their leaves turned mosaic, leading great reduction in the biomass in underground storage organ called for yams. There are two virus transmission systems: bulbil offspring and aphid vectors. We settled each 200m^2 study site in the four forests, recorded the location of each *D. japonica* ramet, and collected leaves for them. We estimated genetic diversity of *D. japonica* using microsatellite markers. The virus infections were confirmed by RT-PCR. In most cases, we found only JYMV (CYNMV) but sometimes found both of them from the same leaves. Infection rate was 0.12- 0.67 in JYMV and 0.10-0.33 in CYNMV. There were no relationships between genetic diversity of host plants and virus infection rate, and between local density of host plants and virus infection rate. In *D. japonica*, negative frequency-dependent selection in the forests was failed to be found. It might be due to that the virulence of these virus in the forest was weaker than that that in the field. When virulence was weak, the ramets belonging to the main genotypes would not be purged from the populations.

INTERACTIONS BETWEEN CLONAL PLANTS AND HEMIPARASITES II: ROOT-HEMIPARASITIC *RHINANTHUS* SPP. SUPPRESS EXPANSIVE CLONAL GRASS *CALAMAGROSTIS EPIGEJOS* IN A SERIES OF FIELD EXPERIMENTS

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Calamagrostis epigejos is a clonal grass frequently expanding to seminatural grassland communities in Central Europe. This expansion threatens biodiversity due to a massive spread of the grass and its ability to competitively exclude most co-occurring species. *C. epigejos* conserves nutrients in its underground tissues (roots and rhizomes) and displays a highly effective resorption of nutrients from the photosynthetic tissues in the end of growing season. As a result, thick layer of slowly decomposing litter is produced preventing establishment of seedlings of other species. In addition, other species do not have access to nutrients captured by *C. epigejos* providing further competitive advantage to the grass. Due to the massive underground resource storage in roots, suppressing *C. epigejos* by standard management practices (mowing etc.) is difficult, laborious and costly. Root-hemiparasitic plants may attach to *C. epigejos* roots and consequently withdraw the nutrients directly from the storage organ of the host. Still, hemiparasites rarely occur in stands of *C. epigejos* spontaneously due to the suppressive effect of the litter layer. In a series of experiments, we demonstrate that *Rhinanthus* species are able to parasitize *C. epigejos* if the litter layer is removed. The suppressive effect of *Rhinanthus* on *C. epigejos* is tremendous. Under certain conditions, *Rhinanthus* spp. can virtually wipe out *C. epigejos* from infested plant communities within two years. This quick response of *Calamagrostis* to *Rhinanthus* infection may be explained by the ability of the hemiparasite to withdraw resources from the below-ground reserve organs which are the keystone of the grass evolutionary success.

ECOLOGICAL IMPLICATIONS OF INTER-PLANT COMMUNICATION

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The long-prevailing Aristotelian paradigm has been that at their low rank on Scala Naturae, slightly above inanimate minerals, plants are mere non-sentient soil-eating blobs; however, accumulating evidence demonstrates that brainless plants are able to not only gauge and respond to their immediate environments but that they can also perceive, integrate and adaptively respond to myriad internal and external signals and cues that are correlated with their future growth conditions. Here, I will shortly present a few novel examples for the abilities of plants to perceive, utilize and relay cues that are emitted from their neighbours that are correlated with both imminent stresses and reproductive opportunities.

UNITED WE STAND, DIVIDED WE FALL? - A SUMMARY OF SEVEN MODELS ON PHYSIOLOGICAL INTEGRATION

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We investigated some ecological and evolutionary consequences of physiological integration between ramets by spatial dynamic models. I summarize the main conclusions from seven papers.In the simulations, we compared the performance of integrated vs. split clones in various environments. Integration proved to be advantageous in two, contrasting cases: (1) when the total amount of resource was low, and it was distributed in a fine-grained, constant pattern, or (2) when the total amount was high, and it was coarse-grained and variable over time. An opportunity for a spatial division of labor between ramets broadened the range of (1) significantly, even when the rule of division was simple. Starting from case (1), and increasing the total amount of resource gradually, we experienced an abrupt change in the optimal strategy from splitting to integration at a well-defined critical threshold. Further tests revealed that only radical splitting was favorable; even very small integrated fragments, which consisted of two ramets, produced the same result as extensively integrated clones. This suggest that in fine-grained environments evolution can hardly “fine-tune” the fragment sizes. Another plant parameter is more easily tunable: that is the shared resource relative to the total amount of resource in a ramet. In general, the results suggest that changes in the spatial and/or temporal distribution of resources can explain evolutionary transitions in both directions: from splitting to integration and back. The transition can be abrupt or gradual, depending on the environmental parameter that is changing.

THE EFFECT OF HABITAT AND ENVIRONMENTAL HETEROGENEITY ON CLONAL *DIANTHUS CALLIZONUS* SCHOTT ET KOTSCHY FROM ROMANIAN CARPATHIANS

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The diploid clonal perennial *Dianthus callizonus* Schott et Kotschy (the little carnation of Piatra Craiului) (Caryophyllaceae Family) from Romanian Carpathians is narrow endemic on alpine and subalpine calcareous screes from a small mountain massif (Piatra Craiului) from the range of Southern Carpathians. The study of individuals in permanent plots during three years comprises inventory of above ground shoots, their phenology, height, internode length, total coverage, together with abundance-dominance of other accompanying species. Spatial analysis of the density of aerial shoots highlighted clonal architecture of *D. callizonus* species. Ramets are randomly or grouped distributed according with spatial heterogeneity of the habitat and integrative plant association (developing „guerrilla" and/or „phalanx" growth strategies). Individuals are smaller on mobile screes (acting as pioneer species colonizing alone new habitats) and taller on fixed screes (dry grasslands). Affected aerial shoots (i.e. due to trampling, grazing, parasites, etc.) present one or two offspring at the ground level, providing the continuous renewal with ramets thus long time survival of the clone. Distribution maps of aerial shoots (according with their phenology) inferred that variation of their density is according with the habitat fostering *D. callizonus* and environmental conditions (especially temperature and humidity). Experimental study of species recruitment by seeds showed the dependency on darkness in this life stage. In the field conditions it was not possible to detect seedlings. Underground buds on rhizomes have different length according with the depth where the underground shoot is localized, substrate structure, environmental conditions, and above ground shoots disturbance. Phenology and life cycle clonal *D. callizonus* depends on micro-habitat conditions, above-ground impact and environmental factors.

ENVIRONMENTAL CONSTRAINTS ON THE RELATIVE ALLOCATION TO SEXUAL AND ASEXUAL REPRODUCTION IN INTRODUCED *MIMULUS GUTTATUS*

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Investing in sexual and asexual reproduction simultaneously can be costly in terms of resources, therefore it is expected a trade-off between both types of reproduction. The correlation between traits are determined by a combination of genetic and environment factors and it can change in magnitude and sign among environments. Trade-offs has an important role in evolution especially in rapid adaptation to new environments mainly because it can limit the adaptive potential of organisms across environments and result in intra-specific differentiation. *Mimulus guttatus* is a herbaceous plant introduced in United Kingdom that shows variation in the allocation to reproduction both in the native and introduced range; although it is unknown yet which environmental factors may drive it. Populations from different latitudes of introduced *M. guttatus* from UK were used in a common garden experiment with the aim to determine if is there a phenotypic trade-off between sexual and clonal reproduction and to what extent such trade-off is affected by availability of resources such as nutrients and space. The experiment had four different treatments in a combination of two factors (big pots and small pots; with and without fertilizer). Measurements of number of floral stems (sexual trait) and number of stolons (asexual trait) were taken from the plants. There was a trade-off between number of flowers stems and stolons in the treatment with big pots and fertilizer. As expected, in big plots plants were significantly taller and invested more in production of flower stems compared to small pots; however production of stolons was not different between treatments. There was no effect of fertilizer in production of flowers stems and stolons between treatments. Overall there was a negative correlation between sexual and asexual traits, but the environment can influence the detection of this correlation. Furthermore under limited space *M. guttatus* reduce sexual reproduction, but continues to invest in clonal reproduction. Therefore clonal reproduction may be a key trait in the success of colonization of this species especially in harsh new environments.

TIME AS A LINK BETWEEN SHOOTS AND ROOTS IN A GRASSLAND COMMUNITY

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In the clonal plants world, temporal scale is of the same importance as spatial scale. Still, mostly only a snapshot is taken to describe patterns in clonal plant communities, especially below ground. What does such momentary view say? We took such a snapshot of root structure of a meadow community and we related it to the species composition above ground, using data from previous eight years. Root structure reflects not only current aboveground species composition, it also can be seen as a result of past processes. Moreover, spatial scale selected for a study can influence temporal scale of the relations. This neglected dimension of the clonal plants space has large consequences for studies on plant competition, plant-soil feedback, plant signalling, etc. Linking spatio-temporal scales above and below ground will be discussed.

CLONAL REPRODUCTION OF THE RARE *HELOSCIADIUM REPENS* IN BELGIAN POPULATIONS

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Helosciadium repens (formerly *Apium repens*) is a small creeping plant belonging to the Apiaceae and is a FFH Annex II species, which is rare throughout its mainly European distribution area. This species propagates sexually and vegetatively by stolons, forming ramets with a low persistence (so-called Fragaria vesca-type). In the Botanic Garden Meise a research project on its conservation biology was initiated, focusing on populations in Belgium, which lies within its core distribution area. Demographical counts were made every month during three seasons in 55 permanent plots of 0.5 m^2, recording the sexual and clonal reproduction of thousands of ramets. This was done in four populations with various sizes and ramet densities, which were moreover subjected to different types and intensities of grazing or mowing. Our results show that ramets can form several new ramets within one month, and that individual ramets may survive for several years, given good circumstances. Within the period of the study, we observed a too high or too low grazing pressure resulting in a very strong decline of three of the four populations, which also impacted on their clonal reproduction. Moreover, within this period extremely warm and dry weather occurred; this allows us to investigate the influence of climate parameters on the clonal reproduction in the largest and most stable population, which has experienced a constant mowing regime over the years. We also examine the relationship between sexual and clonal reproduction for individual ramets under different conditions.

DO SELECTION GRADIENTS OPERATE ON THE GENET OR THE RAMET: COMPARATIVE APPROACH

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One of the main tenets of life history theory is the pervasiveness of trade-offs in the allocation of limiting resources to reproduction, maintenance and growth. These trade-offs are fundamental to all of ecology and evolution, as they restrict the variation in life history strategies that any organism can display. Yet, the amount of variation in life history theories in the plant kingdom has recently been quantified to be drastically larger than previously believed. The quantification of this type of analyses, impossible up until now due to the lack of the necessary high-resolution, demographic data, has recently been facilitated through the launching of the COMPADRE Plant Matrix Database (www.compadre-db.org). I will discuss how, drawing for phylogenetic analyses for hundreds of plant species worldwide, the ability to propagate clonaly drastically unlocks the range of life history strategies than plants can exhibit, and its implications for basic research, conservation biology, and ageing research.

PLANT RESPONSES TO NEIGHBOURING SPECIES ARE CONDITIONAL UPON THE RELATIVE FREQUENCY OF THEIR ENCOUNTERS IN NATURE

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Plant functional traits can vary widely due to phenotypic plasticity to abiotic conditions. Some species also respond to the identity of their competitors while others seemingly lack the ability to do so. We hypothesized that responses to neighbours are shaped by spatial community patterns and resulting variability in neighbour composition. We estimated the frequencies of encountering different neighbour species in the field for 28 grassland species and measured the morphological responses of each species to conspecifics versus a common heterospecific in a common garden. Responses to neighbour identity were dependent on how frequently the experimental neighbours were encountered by the focal species in their home community, with the greatest response observed in species that encountered both neighbours (conspecific and heterospecific) with high frequency. Thus, species traits are likely to be shaped by spatial interactions with other species, and this may importantly influence plant community processes.

ECOLOGICAL, PHYSIOLOGICAL AND KARYOLOGICAL TRAITS PROMOTING INVASIVENESS OF *PHRAGMITES AUSTRALIS*: RESULTS FROM A GARDEN EXPERIMENT

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We address multiple factors assumed to affect plant invasiveness by using the model grass species *Phragmites australis*. In a common garden experiment, we grew 5 replicates of >100 clones collected from all over the world for three years under standardized conditions. We measured a wide range of plant traits related to demography and population dynamics (shoot emergence, height and density, flowering intensity, above- and below-ground biomass production and allocation, rhizome length), herbivory (aphids, chewing herbivores, stem gallers), physiology (leaf chemistry, toughness, water content, photosynthesis rate, specific leaf area) and karyology (ploidy level, genome size). We explore whether these characteristics can be used to distinguish between native (European, African, North-American) vs invasive (North-American, Australian) populations, to obtain insights into ecological, physiological and karyological mechanisms operating during between- and within-continental invasions. We hypothesise that plant traits directly affect invasiveness and are co-shaped by evolutionary history in the population's geographic origin and by environmental variation in the introduced range. In addition, cytology and geography also affect invasiveness indirectly by influencing ecological traits. Disentangling these complex issues can provide novel insights into the mechanisms of invasion at the population level.

ECOLOGICAL CONSEQUENCES OF GENOME GROWTH AND POLYPLOIDY

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Vascular plants show over 2300-fold variation in the size of their genomes resulting mainly from activity of retrotransposons and historical or recent polyploidy. Increased genome size has several passive, instant and immediate effects on functioning of plant cells which may substantially affect plant's morphology, ecology and success in certain environments. These effects include namely increased minimal cell size, prolonged duration of cell cycle and higher DNA-replication associated phosphorus demands. Currently growing data on plant genome sizes, species traits and distribution allows these hypotheses to be robustly tested, further developed and put into new contexts which may significantly improve our understanding of determinants of plant form, function and associated spectra of plant available life-history and ecological strategies. Beyond passive effect of DNA amount, prevalence of some traits and ecological strategies in polyploids (e.g., vegetative reproduction), seem also due to their selection during establishment of polyploids in the population of their diploid parent(s). Here I will briefly summarize the current theory and some new hypotheses on the effect of genome size and polyploidy on species ecology and distribution and provide examples of these effects from our ongoing research of genome size variation in the Czech flora and the data from CLOPLA database of clonal plant traits.

THE CLONAL *POA ALPINA*, A SEED- AND BULBIL- PRODUCING PLANT LIVING IN THE BEST OF ALL WORLDS?

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Poa alpina, one of the most common and widespread fodder grasses of the European Alps, reproduces either by seeds or clonally by bulbils. In many populations, both seed- and bulbil-producing individuals occur together. Seed-producing plants are apomicts, but the frequency of seeds occurring by meiosis was found to be high (8 %). Molecular diversity in 74 grassland sites across the Swiss Alps indicated considerable genetic diversity among populations increasing with geographic distance. Populations of *Poa alpina* were differentiated molecularly among land use types, and among sexually and vegetatively reproducing populations. The occurrence of seed-producing individuals decreased, and that of bulbil producing individuals increased with elevation, in line with the hypotheses of an adaptive advantage of clonal reproduction in harsher environments. Allocation to reproductive biomass was found to be higher in plants from grazed compared to mown sites, indicating an adaptive advantage of reproduction in pastures and of competitive strength in mown grassland. In a common environment, bulbil-producing plants were generally less vigorous than seed-producing plants, but reciprocal transplantation did not reveal adaptation due to origin or elevation, but indicated high phenotypic plasticity in this species. In conclusion, by its seed- and bulbil reproducing capacity and by adjusting plastically to variable conditions, *Poa alpina* is able to occupy sites across a large elevational and ecological range. The prevailing occurrence of bulbil-producing plants at high elevation is probably due to an advantage of bulbils at cold sites with poor soil and short growing seasons.

INTERACTIONS BETWEEN CLONAL PLANTS AND HEMIPARASITES I: TESTING THE CLONAL INTEGRATION HYPOTHESIS

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Clonal plants have recently been suggested as possibly high quality hosts for (hemi)parasitic species. Conversely, clonal plant might suffer more damage from parasitism than non-clonal hosts. This is based on the clonal integration hypothesis which states that a (hemi)parasite integrates to the host clonal network which provides more resources than just the infected ramet. The host population is more damaged because the resources provided to the parasitized ramets by its non-infected neighbours can be also withdrawn by the parasite, which may result in more vigorous growth of the parasite and its higher sink strength. We test the clonal integration hypothesis in a pot experiment with hemiparasitic *Rhinanthus alectorolophus* and clonal grass *Calamagrostis epigejos* as the host. The experiment was conducted using long rectangle pots containing two interconnected ramets of *Calamagrostis*. Above-ground biomass production of each of the ramets was determined in the first year of the experiment. Subsequently, seeds of the hemiparasite were sown in the close surrounding of the shoots of one of the ramet in half of the experimental pots. In the same time, connection between the ramets was cut in half of the pots. Above-ground biomass of infected and non-infected ramets and *Rhinanthus* will be monitored. The clonal integration hypothesis will be supported if i. *Rhinanthus* growth is positively affected by connection between the ramets, ii. if non-infected ramets connected to infected ramets perform worse than those that are not connected.

INDUCED FORAGING FOR DEFENSE IN A METAL HYPERACCUMULATING CLONAL PLANT

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Metal tolerance and hyperaccumulation are common traits in many Brassicaceae species. A popular, albeit rarely tested theory is that hyperaccumulation of heavy metals may serve as anti-herbivore defense. If this is the case, then clonal plants could be able to actively forage for heavy metals in the soil if attacked by herbivores. This would constitute a novel mechanism of foraging in clonal plants. Here, we use a clonal plant, *Arabidopsis halleri*, which is known to accumulate heavy metals, to combine a test for anti-herbivore defense with the well-known ability of clonal plants to forage for resources. We tested the hypothesis that active foraging for heavy metals can be induced both within and between ramets when plants are attacked by herbivores. We also tested whether plants from uncontaminated soils would avoid contaminated soils if there is no herbivory and switch their foraging behaviour when attacked. We used both a split-root single-ramet design and a design with two connected ramets to test for the effect of herbivory (clipping plus jasmonic acid vs. no simulated herbivory) and plant origin (from contaminated soils vs. from uncontaminated soils) on root foraging behaviour. Our findings indicate that without herbivory, plants from uncontaminated soils avoided root proliferation in soils enriched with cadmium, and that this behaviour switched when herbivory was simulated, i.e. more roots were produced in Cd enriched soils. Plants that originated from contaminated sites showed no difference in root proliferation between soil types irrespective of herbivore treatment. This indicates that for plants not adapted to contaminated soil, root proliferation in contaminated soils comes at a cost and is only realized when defense is needed. Our overall results indicate a novel foraging syndrome in clonal plants, namely, inducible foraging for plant defense substances in the soil.

GENET DYNAMICS AND RECOVERY PROCESS OF A DWARF BAMBOO POPULATION AFTER A SYNCHRONOUS FLOWERING AND DIE-OFF

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Understanding population dynamics is a central topic in plant ecology. In clonal plant species, however, studies of genet dynamics were often not feasible because individual genets were not readily distinguishable in the field. Sasa kurilensis is a mass-flowering dwarf bamboo that propagates vegetatively by extending rhizomes and often dominates the understory of beech forests in northern Japan. In this study, we examined how light environment affects genet dynamics and recovery of a population of *S. kurilensis* after a synchronous flowering and die-off. In 2005, 10 years after the die-off, we established six 3 x 3 m plots under three levels of light environments, and all the culms within the plots were tagged, genotyped with microsatellite loci, and monitored for its demography until 2012. Aboveground biomass has recovered much slower under closed forest canopy compared to canopy gaps, but the recovery rate under closed canopy has accelerated since 2005. The number of genets have decreased and genet mortality was greater under canopy gaps with greater initial densities, while the number of genets have increased under closed forest canopies because recruitment rate via vegetative growth exceeded mortality rate. Large genet sizes (i.e. the number of culms) and high heterozygosities were positively associated with genet persistence, while the genets that have recruited via vegetative growth produced culms with larger diameter compared to those that have persisted in the plots. Irrespective of light conditions, substantial proportions of standing biomass in 2012 derived from genets that were absent seven years ago. Our results emphasize the role of vegetative growth and inter-genet competition in population dynamics and recovery of this clonal species.

THE ECOLOGICAL AND EVOLUTIONARY RELEVANCE OF ENVIRONMENTALLY INDUCED NON-GENETIC TRANSGENERATIONAL EFFECTS

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The heritability of environment-induced non-genetic effects is currently a topic of great interest in plant biology and ecology. We know that heritable adaptive responses to the environment may also evolve from variation in epigenetic modifications of the genome, even in the absence of DNA sequence variation. Such epigenetic processes may therefore provide an important and versatile additional mechanism for plants to rapidly adapt to environmental change. However many of these environment-induced transgenerational effects are context dependent and are therefore often dismissed as noise. Consequently the interpretation of its ecological and evolutionary relevance is difficult. Here I present a unique study in which we compare plant responses to exposure of different environments over single and multiple generations. Effects of ancestral environments were detectable in all traits and in all environments, but the magnitude and direction differed between offspring environments. In addition, different responses to a common stress factor were found, depending whether the stress factor was applied in a single generation or over multiple generations. The results imply that transgenerational effects commonly occur and may have a considerable impact on plant phenotype, plant performance and the way plants respond to their environment. The role of epigenetic inheritance as a prime mechanism for these observed transgenerational effects will be discussed.

IMPACTS OF CLIMATE CHANGE ON GLOBAL ALIEN PLANT INVASION IN CONSERVATION AREAS: DOES CLONALITY MATTER?

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Conservation areas (CAs) play important roles in biodiversity conservation, but are increasingly threatened by biological invasion. Global climate change may alter geographic distribution ranges of alien plant species (APS), and differentially affect invasion of clonal and non-clonal APS. Therefore, there is an urgent need to understand how climatic change affects invasion of APS in CAs and whether plant clonality matters. We used three species distribution models (GLM, GAM and MaxEnt) to project potential distributions of the 36 clonal and non-clonal APS from the list of the "100 of World's Worst Invasive Alien Species" in CAs in 16 different biomes under the current and three future climate scenarios. At the global scale, climate change had little impact on the invasion probability of APS into CAs and clonality showed little impact. However, climate change markedly increased the invasion probability of APS in seven biomes, and decreased that in five biomes. Furthermore, effects of climate change differed greatly between clonal and non-clonal APS in some biomes. For instance, the effect of climate change was much larger in clonal APS than in non-clonal APS in Inland Water, and Temperate Grasslands, Savannas and Shrublands, but was much smaller in Tundra. We conclude that climate change can alter plant invasion in CAs in some biomes and such an effect may depend on plant clonality.

VOLATILE ORGANIC COMPOUNDS (VOCS) DRIVE NUTRIENT FORAGING IN THE WOODLAND STRAWBERRY, *FRAGARIA VESCA*

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Studies of clonal plant foraging generally focus on growth responses to patch quality once rooted. Here we explore the possibility of true plant foraging; the ability to detect and respond to patch resource status prior to rooting. We suggested and tested a mechanism by which plants detect and respond to volatile organic compounds (VOCs) emitted from nutrient-rich substrates. Two identical greenhouse experiments were conducted (one in the spring, the other in the fall); individual daughter ramets of the *Fragaria vesca* (woodland strawberry) were exposed to the air above live (non-sterilized) or dead (sterilized) substrates. VOCs emitted by the substrate were collected and analysed by stir bar-head space extraction gas chromatography-mass spectrometry using a method modified for soil and litter systems. Contact between daughter ramets and substrate was prohibited. Daughter ramet root biomass was significantly larger over live versus dead substrate. Root:shoot ratio also increased in response to exposure to live substrate; a morphological response we interpret as indicative of active nutrient foraging. Mother ramet size was correlated with daughter ramet root biomass over live but not dead substrate. We conclude that exposure to live substrate drives positive nutrient foraging responses in *Fragaria vesca*. Volatile profiles emitted from live substrates consisted primarily of short-chain fatty acids while dead substrates emitted a higher proportion of aldehydes, ketones and terpenes; the former classes tend to stimulate plant growth, the latter to suppress it. From the results of the gas-chromatography-mass-spectrometry data, we created mixtures of commercially available volatiles in concentrations similar to that of substrate used in previous experiments. We applied the volatile mixtures to sand and investigated the trajectory of stolon growth in response to combinations of volatile patches. We found that stolons of *F. vesca* preferentially grow into substrates rich in short-chain fatty acids versus aldehydes, ketones, terpenes and a water control. We conclude that developing strawberries are able to detect and respond to the nutrient environment via communication between the plant and microflora in the substrate.

DOES CLONALITY CONSTRAIN PLANT COMPETITIVE BEHAVIOUR?

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Plant behaviour, realized by growth plasticity, is one of the topics notoriously connected to clonal plant research. Do we investigate the same topic when comparing plant behaviour of clonals and non-clonals? Clonality may predispose species to exhibit certain types of behaviour that may be rarely seen in non-clonals. Our experiment with several dozens of clonal and non-clonal species allows us to shed light on the role of species bauplan that shapes plastic reaction to light shortage, either connected or not with the signal of neighbour presence.

ON THE RELATIONSHIP BETWEEN COMPETITIVE ABILITY AND DEGREE OF SPATIAL AGGREGATION IN CLONAL PLANTS

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Several theoretical consideration show that if competitive ability is viewed as a behavioural trait the properties of plants determining spatial patterns and competitive ability could co-evolve, resulting in greater dispersal in stronger competitors and reduced competitive ability in spatially aggregated species. We found, by combining field observations and results from a pot experiment, that species exhibiting strong conspecific aggregation and infrequent heterospecific encounters in the field maintained greater growth in competition with conspecifics than with heterospecifics. In contrast, species that mostly encountered heterospecific neighbours in the field achieved greater growth when surrounded by heterospecific than conspecific neighbours, indicating greater competitive ability. The observed patterns of conspecific aggregation were related to variation in clonal dispersal characteristics and there was a direct positive relationship between clonal dispersal distance and competitive ability.

POSTERS

WHITE-SAND UNDERGROUND FORESTS: A UNIQUE AND ENDANGERED VEGETATION TYPE FROM BRAZILIAN SAVANNAS

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Underground trees are a rare and peculiar growth form known for over a century from tropical savanna vegetation with seasonal droughts and a fire regime, both from Africa and the Brazilian Cerrado province. In this study we describe vegetation dominated by underground trees belonging to ten sympatric species: *Anacardium humile* A. St.-Hil., *Andira humilis* Mart. ex Benth., *Byrsonima subterranea* Brade and Markgr., *Cordiera humilis* (K. Schum.) Kuntze var. *humilis*, *Duguetia furfuracea* (A. St.-Hil.) Saff., *Erythroxylum deciduum* A. St.-Hil., *Eugenia punicifolia* (Kunth) DC., *Jacaranda decurrens* Cham., *Ouratea floribunda* (A.St.-Hil.) Engl., and *Psidium cf. australe* Cambess. Of the 121 vascular plant species sampled by relevés in the study site, at least 67 species (55%) are geophytes. Such a high proportion with underground systems such as lignotubers, bulbs and corms has never been reported from any Neotropical plant community and was unexpected in shallow white-sand. A brief vegetation description is complemented by floristics and seasonality data for each layer and a discussion of the possible convergent origins of the underground tree life form in several unrelated taxa. The underground forest described herein is currently threatened by mining and cattle. This survey is meant to subsidize further vegetation studies as well as measures aimed at the protection of underground forests.

POPULATION GENETIC DIVERSITY OF THE CLONAL SELF-INCOMPATIBLE HERBACEOUS PLANT SPECIES *LINARIA VULGARIS* ALONG AN URBANIZATION GRADIENT

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How increasing urbanization affects biodiversity is one of the most understudied aspects of global change biology. It is, however, known that it may negatively affect plant population genetic diversity in numerous ways, for example through its negative effects on plant population size, between-population connectivity, and reproductive success. Therefore, it is important to investigate to what extent different levels of urbanization result in these negative phenomena. We have used microsatellite markers to investigate urbanization effects on population genetic structure of 23 populations of the self-incompatible, partially clonal herb Linaria vulgaris which were sampled across a gradient of urbanization. Clonal diversity as measured by Pareto-parameter varied between 1.11 and 2.97 and was negatively correlated to both the degree of urbanization and population size. Urbanization and population size were not interrelated. The least clonally diverse populations also experienced significantly reduced seed set. Irrespective of the degree of urbanization, *L. vulgaris* populations exhibited strong genetic differentiation (FST = 0.33) and there was no significant correlation between genetic and geographic distances, suggesting low gene flow among populations. In conclusion, we showed that urbanization negatively affected fitness of *L. vulgaris* populations through decreasing their clonal diversity and reproductive success, an effect that may be exacerbated by the low gene flow between populations. Although the effect was modest, the results could probably be extrapolated to bigger cities where it would be considerably more pronounced.

CHECK-LIST OF ROOT-SPROUTERS IN THE CZECH FLORA: MAPPING THE GAPS IN OUR KNOWLEDGE

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Root-sprouting ability is one of the key morphological features of clonal plants which facilitates bud bank formation and vegetative reproduction. To support researches interested in adventitious bud and shoot formation in any field of plant science, we compiled a list of plants considered as capable of root-sprouting from the literature and the CLO-PLA database for the flora of the Czech Republic. Only a small proportion of root-sprouters, however, have been studied so far, and for most of them we lack detailed data on anatomy, morphology, ecology and physiology of adventitious shoot formation. For 145 species regarded as root-sprouters out of 343, only rudimentary information is available. Here we provide basic analyses concerning the distribution of root-sprouting ability among life forms, plants with different rarity and invasive status, and taxonomic groups. Root-sprouters occur in 67 families, mainly dicotyledonous. The largest number of root-sprouters are members of the Asteraceae and Rosaceae families (41). Root-sprouting ability usually plays a supplementary (additive) or regenerative role in the plant life cycle. This check-list may serve as a source of reference and their quality on adventitious bud and shoot formation not only for Czech but partly for European temperate flora, and may inspire future studies of this clonal trait in other regions of the world.

„PLANT IN THE LABYRINTH" – PATCH STRUCTURE AND PLANT ARCHITECTURE LIMITING CLONAL GROWTH

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Clonal growth theoretically allows a plant to fill all the available space in a resource patch. However, this process is limited by the shape of the patch and the rules of plant growth, concerning the spacer length, the frequency and the angle of branching. We investigated clonal growth by a dynamic spatial model, varying the grain of habitat patchiness relative to the spacer length, and the resource-rich portion of the area from p=10 to 100%. We assumed that the plant could not enter into any resource-poor site, i.e., its growth was limited to the resource patch into which its propagule had arrived. At every parameter combination, we tested the efficiency of occupation from 1000 starting points. The results show that when p was low, thus, the suitable habitat consisted of small, fragmented patches, occupancy was not significantly influenced by the rules of growth. The plant occupied the same ratio of the patch independently of the growth rule. When p approached a critical threshold (the percolation threshold, pc=0.5), the habitat became dominated by a single, large patch with filamental structure. Occupation was strongly limited by the plant's ability to find narrow streets in this „labyrinth". Increasing p further, the dominant patch provided more space for finding pathways and turning, thus, occupancy increased significantly. Increasing the spacer length or decreasing the frequency of branching made occupancy less efficient. Restricting the branching angle into a narrower range did not decrease the efficiency significantly; it could even increase it in some cases. When the grain of resource patchiness was coarser, we gained similar results but consistently at lower values of p, indicating that the same amount of resource distributed with higher autocorrelation may facilitate occupancy. There was no case when plant was able to fill all the available space; gaps always remained open to be occupied by other species, depending on the actual species' architecture.

DOES PHYSIOLOGICAL INTEGRATION PLAY AN IMPORTANT ROLE FOR THE INVASION OF THE CLONAL GRASS *ELYMUS ATHERICUS*?

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In the past decades, the tall native invasive grass *Elymus athericus* has been increasing its frequency and dominance on salt marshes along the Wadden Sea coast. This successful clonal plant has the ability to spread widely and quickly through rhizomes after cessation of livestock grazing. Research so far focused on elevation, sedimentation and drainage conditions in order to determine which factors may affect the increased occurrence of *Elymus athericus* in salt marshes, and also changes in species composition caused by Elymus athericus and depending trophic interactions were monitored. To date, many studies were published to document the role of physiological integration of ramets during the invasion of clonal plants, but not of *Elymus athericus*. We investigate the role of physiological integration among ramets for the invasion of the clonal grass *Elymus athericus* under different flooding regimes. For this, clones of two ecotypes of *Elymus athericus* (one from the high marsh, the other from the low marsh) will be grown in paired pots, in which parent ramets are connected to daughter ramets via their common rhizome. Clonal integration treatments will then be applied to both ecotypes of *Elymus athericus*, meaning that rhizomes between parent and daughter ramets will be severed or left intact. The parent pots will be kept without flooding treatment and labeled by $^{15}NH_4NO_3$ while daughter ramet pots will be supplied with an amount of unlabelled nitrogen equal to the parent ramets. Daughter ramet pots additionally will be the subject of flooding treatments (flooding or non-flooding).

DOES RESOURCE SHARING HELP TO WIN IN COMPETITION?

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Plants with clonal integration of ramets have been shown to cope better with environmental heterogeneity. Moreover, it is often assumed that clonal integration could be beneficial in competition with other plants as the competitors themselves generate heterogeneity in both belowground resources and light. However, this hypothesis has not been yet properly tested. Study of experimental communities poses one of possible approaches to this issue. Prior to conducting our own experiments, we have started with exploring data from already running long-term biodiversity experiments. In these experiments, grassland communities were established by sowing different combinations of species to experimental plots. These communities vary in number of sown species as well as in proportion of clonally integrated species. Biomass and/or percentage cover of individual species are reported annually, which allows us to observe success of clonally integrated species in different communities. We address following questions: (i) Does biomass of clonally integrated species in the communities differ from their expected biomass? (ii) Does proportion of clonally integrated species affect species richness and productivity of the communities?

DEMOGRAPHY OF RAMETS IN A RHIZOMATOUS CLONAL HERB (*SAMBUCUS EBULUS* L.)

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Local populations of a rhizomatous herb *Sambucus ebulus* L. were studied in three localities in SW Slovakia, Central Europe (Báb, Trnava, Bratislava), located in agricultural and urban landscape. The clonal plant species forms tall (> 1.5 m, range 1.2 – 2.1 m), close (100% total cover) and dense (range 11-32 i.m-2) discrete patchy stands of the plant community (*Artemisio-Sambucetum ebuli*). The vegetation patches exhibit low species richness, low alfa diversity and equitability but high dominance of the dwarf elder by cover and biomass. Synchronized rapid growth of S. ebulus above-ground shoots (ramets), starting in the end of March and/or in the beginning of April, and formed the close canopy in May, supports the dominant role of the species in the community. In this study, growth, survival, and reproduction of ramets was monitored in permanent 1x1 m plots located within the patches. In summer each ramet survived can produce and produced inflorescences and fruits (sexual reproduction) but clonal growth of rhizomes and ramets (asexual reproduction) is evidently more important in the reproductive demography of *S. ebulus*. The perennial genets produced every year more herbaceous ramets than can survive in one growing season. This vegetative over-production resulted in high mortality of young shoots in early summer and summer months under the close canopy of tall (dominant) plants.

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POPULATION STRUCTURE OF A BULBIFEROUS CLONAL PLANT *GALANTHUS NIVALIS* IN TWO TEMPERATE DECIDUOUS FORESTS IN SW SLOVAKIA

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Vernal geophytes are clonal plants growing in early spring/spring in temperate deciduous woodlands where they utilize favourable light conditions (high solar radiation) in the woodland understoreys. The temperate woodland species *Galanthus nivalis*, a bulbiferous clonal plant, is the first understorey plant to emerge and flower in late winter and early spring. In an oak-hornbeam forest at Báb near Nitra, SW Slovakia (former I.B.P. Forest Research Area, now ILTER site) dispersion, age and size structure as well as phytomass of two local populations of the species were analysed. Sample plots (size 1x1m) along line transect of 100 m length were used for counting and measurements of flowering and vegetative plants. The plants were spatially distributed contagiously (aggregated dispersion of the populations). The population density varied between 1 to 231 flowering plants per 1 m^2. Large differences were found between two coenopopulations in phenology, plant traits as well as the population characteristics. In *Primulo veris-Carpinetum* more flowering and less vegetative plants occurred in comparison with West Carpathian *Carici pilosae-Carpinetum* forest.

The study was supported by VEGA within the research project „Ecosystems and their effects – ecosystem services in rural areas“

ADAPTIVE PARENTAL EFFECTS IN AN APOMICTIC *TARAXACUM BREVICORNICULATUM*

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Transgenerational plasticity is a mechanism allowing plants to adjust their phenotype in response to changing environment and pass these adjustments to the offspring. This phenomenon, called parental effects (PE), has been thus far mostly studied on non-clonal plants, but recent work suggest it can have important implications for clonal plants. Not much is known if PE represent a random or adaptive response to changing local conditions. We asked 1) if PE are important in clonal plants; 2) if PE are adaptive; and 3) if PE are mostly mediated through shoot or root traits. In order to investigate PE and their adaptiveness in clonal plants we conducted a multiple-generation greenhouse experiment with reciprocal water stress treatment using a single clone of apomictic dandelion *Taraxacum brevicorniculatum*. We found evidence of PE in a clonal apomictic dandelion. PE were expressed by five out of seven traits measured (root and shoot biomass, root and leaf area, root length), whereas PE were adaptive in two traits (shoot biomass and root length). We conclude that PE are important in clonal apomictic plants like dandelions, they can be adaptive to water stress conditions and mediated by both shoot and root traits.

DIFFERENCE OF GROWTH PHENOLOGY BETWEEN CLONAL AND NON-CLONAL PLANTS

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Phenology is an important dimension of niche differentiation in plants. While a number studies have focused on flower phenology, very little data are available on growth phenology because of the difficulty of phenology quantification and data collection, especially for large sets of species. Here we overcome the difficulty by collecting data on growth phenology from a unique plant collection in the Botanical Garden of Charles University in Prague. The plant collection makes possibility to collect frequent recordings over large sets of species during the vegetation season. We expected to answer these questions: 1) what are the patterns of growth phenology over large sets of species? 2) What is the difference of growth phenology between clonal plants and non-clonal plants? 3) What is the difference of growth phenology between monocarpic plants and polycarpic plants? 4) What do these differences change in each family? In a preliminary test, 3 individuals of each of 54 species stratified by families were selected, and their height (H) and width (W) were recorded once every 1-2 weeks from April to October. Then, a logistic curve using growth trajectory of plant size (L, calculated by L=√(H^2+W^2)) was fitted using nonlinear least squares model. This yielded two parameters: temporal shift (a) and relative growth rate (b). By plotting a against logarithm of b, the results showed the pattern of growth phenology among species. This preliminary analysis shows, expectedly, strong phenological differentiation among species. Non-clonal plants grow faster and earlier than clonal plants, which was particularly clear in Caryophyllaceae and Lamiaceae. Also polycyclic species grow faster and earlier than monocyclic species, especially on Family Asteraceae, Lamiaceae and Rosaceae. The results indicated the growth phenology varied among species depending on their clonality and cyclicity. This year, data on growth phenology about 500 species will be collected in the same garden. And we expect to answer the above questions on even large sets of species.

SPATIAL ORGANISATION AND CLONAL GROWTH OF ALPINE *DRABA* SPECIES IN THE CARPATHIANS

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Carpathian alpine *Draba* have a restricted distribution, being endemic for an area or vulnerable due to their rarity. Thus, understanding the reproductive strategies can help improve their conservation measures. *Draba* grows in more or less dense rosette cushions in rocky habitats, in small size population and occupy a limited territory. Although rosette plants form an important group of species in the alpine habitats, due to their special adaptation in manipulating the environmental conditions, little is known about their spatial organization in a vegetation community. We analyse morphological characters and clonal reproduction potential to determine the importance of clonal reproduction in some population of alpine endemic *Draba* species in the Carpathian Mountains (Romania) and the impact on the competition and population structure.

USING TRANSCRIPTOMES TO IDENTIFY GENETIC MARKERS FOR SALINITY TOLERANCE IN *PHRAGMITES AUSTRALIS* AND FACILITATE WETLAND RESTORATION

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Salinity is increasing in the Gippsland Lakes which is a Ramsar listed wetland system in southern Australia of international importance. Changes in salinity are affecting the integrity of vegetation communities containing *Phragmites*. This has prompted an interest in the rapid identification of salt tolerant lineages of *P. australis* that could be used in the rehabilitation of wetlands and lake foreshores. *Phragmites* clones were sampled from sites across the Gippsland Lakes with a range of salinity levels. Replicates of each clone were grown in containers containing water of varied salinity ranging from zero to 16 gL^{-1} NaCl. Small sections of leaf and rhizome tissue were sampled from six pairs of clonal plants grown in either fresh or high saline water and RNA isolated. We followed an RNAseq protocol to allow the comparison of transcriptome data among and between clones and treatments. This sequence data will be used to identify genes associated with salinity tolerance in P. australis and to develop genetic markers that allow rapid screening of plants for this trait. We expect expression levels for genes associated with salinity tolerance levels to vary among treatments within clones and a combination of varied gene expression and allelic differences within treatments among clones. Our initial results will be presented with a discussion of the potential of this approach for biodiversity conservation.

THE ROLE OF CLONALITY UNDER DIFFERENT DEGREES OF MEADOW ABANDONMENT IN A LONG-TIME EXPERIMENT

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Meadows underlie serious changes in Middle Europe. Intensification or abandonment are the main processes that have enormous influence on species composition and diversity in meadows. Cessation of mowing leads to serious species losses depending on the nutritional status of the systems. Nearby Vienna, we tested how meadows from different nutritional status change during different degrees of abandonment over 15 years. Nutrient rich and wet meadows showed species losses by more than 50% within few years under full abandonment whereas semidry nutrient poor meadows lost only 25% of species in the same time period. Woody invaders played only a role in plots nearby forests. The most impressive qualitative changes were driven by few non-clonal tall growing as well as clonal perennial herbs. The former tend to dominate the early successional stages, the latter in the later stages. Partial abandonment was tested by plots cut every second year. Species diversity was reduced in nutrient rich and wet systems earlier compared to the semidry poor meadows. But, the process took more time. After 15 years of partial abandonment, the nutrient rich meadows seem to stabilize at a diversity level of 50%, the wet meadows reach about 60% (still decreasing), and the semidry nutrient poor systems stabilize at about 70% of the original species number. As non-clonal meadow species depend very much on the availability and longevity of gaps for successful generative reproduction their chance to get re-established is higher in meadows with low productivity. They have at least every second year a chance to regenerate from seeds, whereas in nutrient rich systems the spatial gaps are closed too quickly after the cuts. Vegetative (clonal) regeneration turned out to be most successful in nutrient rich meadows. Clonality per se was not enough to succeed. Growing tall and bearing many or big leaves along the stems is an essential growth character to outcompete other species. Additionally, summer-green clonals that provide high amount of dead and slowly decomposing biomass turned out to impede any seedling establishment. Clonal regrowth turned out to be the only way to persist. The maintenance of mowing and biomass removal should be the main goal in conserving the biodiversity in meadows.

EFFECT OF LOCAL PATHOGEN ON TRANSLOCATION IN CLONAL PLANT

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Clonal plants can use their connections to share and exchange resources. This gives them advantage over the non-clonal plants in certain situations (e.g. high heterogeneity). The resource flow generally follows source-sink dynamics that is governed by heterogeneity in uptake and consumption and by apical dominance. Unfortunately, there is much less known about the drawbacks of clonality – namely about the effect of diseases. It is known that pathogens such as viruses are able to infect the plant and travel within the whole clone. But other pathogens might be able to infect the clonal fragment locally and use the source-sink dynamics to flourish locally. Therefore I plan to perform an experiment to find out if the healthy parts are exploited by the ramet infected by the local pathogen (powdery mildew). The study system will be the plant *Duchesnea indica* and the pathogen *Podosphaera aphanis*. The outcome can be in the opposite direction as well leading to separation of the infected part or increased growth due to hormonal changes. The results and their implications will be discussed at the meeting.

THE LOST OF SEX IN TRIPLOID *GLADIOLUS TENUIS* (IRIDACEAE) AND FORMATION OF GIANT CLONE

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Many of perennial herbaceous plants are able to reproduce vegetative in addition to sexual reproduction. Sometimes such plants lose the opportunity for sexual reproduction. We have studied the case of sterility in a significant part of area in triploid populations (2n=3x=45) of *Gladiolus tenuis* M. Bieb. We first recorded the presence of a large clone of *G. tenuis* to the east of Volga River, using enzyme analysis. Then we used AFLP fingerprinting to genotype 55 samples from 10 populations of *G. tenuis* and one population of *Gladiolus imbricatus* L. The analysis revealed an extremely low genetic diversity in sterile triploid populations and a rather high genetic diversity in fertile tetraploid populations (2n=4x=60) in the main part of the area. Genetic distances between fertile and sterile populations of *G. tenuis* were similar to the distances between studied species of gladioli. Thus, one genotype formed a clone and spread over 800 km using daughter corms. The study of the reproductive features of *G. tenuis* suggests that the cause of sterility is self-incompatibility of the clone.

THE STRUCTURE OF GENOTYPIC DIVERSITY AND THE STATE OF THE REPRODUCTIVE SYSTEMS IN POPULATIONS OF CLONAL *TULIPA RIPARIA* (LILIACEAE)

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The genotypic diversity and spatial structure in eight populations of the most northern triploid (2n=3x=36) tulip *Tulipa riparia* were studied along the river systems on the Southern Urals. The analysis of nine polymorphic enzyme systems (ADH, IDH, SkDH, PGI, PGM, FDH, NADHdh, C-EST, GOT) was performed to identify clones. This report identifies both monoclonal populations (D = 0), and population with multiple genotypes – from 3 to 12 (D from 0.73 to 0.91), with a high level of heterozygosity. The transfers of propagules (bulbs) across rivers, and the resettlement of one genotype along the bank and on different sides of the river, were detected. At the same time, there is the effect of "isolated" or "closed" populations, as even the neighbouring population, with few exceptions, has their own set of genotypes. Assessment of the state of the reproductive system suggests the presence of a rare breeding seed, thus supporting diversity.

STOLON GROWTH IN *FRAGARIA VESCA*

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Fragaria vesca is a common model species for clonal, stolon-based spread. However, mechanism that underlie stolon growth are not fully understood. Therefore, we performed greenhouse experiment that tested effects of nutrient availability and light supply in stolon production. We found that light supply did not play any significant role in stolon initiation, but led to longer stolons. On the other hand, fertilisation played the major role in all aspects of stolon production: it increased number of stolons, their size and time of initiation. More fertiliser led to bigger plants, but direct effect of fertilization was stronger than correlation of stolon production with plant size. Also, bigger plants tended to flower more, but flowering plants of the same size as the non-flowering ones produced less stolons. These results indicate that reproduction, either sexual or clonal, is directly conditioned by site productivity and is partly autonomous to plant size. Moreover, these two modes of reproduction seem to be involved in resource allocation trade-off.

ENFORCED CLONALITY: SHOULD IT BE TAKEN INTO ACCOUNT?

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Clonality is defined as a vegetative growth resulting in production of potentially independent offspring (ramet) from a maternal plant. Splitting of a clone to ramets is usually spontaneous and takes from months to decades to be completed. However it may be also realized suddenly by external force which fragmentizes a plant. When plant fragments are capable to survive and regenerate we can speak about enforced clonality. Although this process is not so essential for plants which are otherwise splitting into ramets spontaneously it is crucial for non-clonal plants. Enforced clonality therefore plays important but so far not fully recognized role in recurrently disturbed habitats. To explore importance of enforced clonality for population establishment and persistence we set up five-year garden experiment with short-lived non-clonal *Barbarea vulgaris* and *Barbarea stricta*, species differing in the ability to regrowth from root fragments. We examined fitness (whole-life seed number) of enforced ramets in relation to fitness of uninjured plant and to fitness of plant germinating from the seed bank at the time of disturbance. In *B. vulgaris*, fitness of enforced ramets was found to be higher than fitness of both, uninjured plant and plant regenerated after disturbance from the seed bank. This advantage of enforced clonality was less pronounced when disturbance occurred lately in plant life. In *B. stricta*, fitness of enforced ramets was equal or lower than fitness of uninjured plant and plant emerging from the seed bank at the time of disturbance. Obtained results are in agreement with habitat preferences of examined species as *B. vulgaris* occurs on more disturbed habitats than *B. stricta*; body fragmentation is more probable and thus enforced clonality is more advantageous there. Our results imply that enforced clonality should be taken into account when studying population dynamics of plants from recurrently disturbed habitats.

CLOINVADER: UNDERSTANDING THE ROLE OF CLONAL INTEGRATION IN PLANT INVASIONS

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One core research question in invasion biology is to explain why some species become invasive while others do not. In spite of the research effort developed in the last years to explain biological invasions, this is a process still not well understood. Some plant characteristics might explain the success of invasive species better than others. In particular, clonal growth has been pointed out as an attribute that could contribute to the invasiveness of plants. However, and although many of the most aggressive invasive plant species show clonal growth, little research has been conducted to determine the role of clonal traits in successful invaders. Clonal plants play important roles in many ecosystem processes and dominate many plant communities. One of the most remarkable traits associated with clonal growth is the capacity for physiological integration (resource sharing between connected members of the clonal system). Recent studies have demonstrated that clonal integration increases survival and growth of aggressive invaders. However, future research should be conducted to determine differences in clonal integration between exotic non-invasive and invasive congeners, and between populations from native and invaded range to determine the presence of adaptive evolution of clonal traits during the invasion process and therefore elucidate the role of clonality in biological invasions.

SHOOT APICAL MERISTEM AS A PLACE OF MAJOR TRADE OFFS IN CLONAL PLANTS

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Shoot apical meristem (SAM) is a set of rapidly proliferating cells located at the tip of the shoot apex that produce all aboveground plant organs – leaves, nodes, internodes and flower buds. Size of the SAM determines the size of developing plant organs, as well as the size of the whole plant and the amount of produced seeds. In turn, the size of SAM reflects a number of evolutionary and ecological constraints. The size of the SAM is predetermined by the seed size, as the SAM is already founded in the embryo, or by the size of developing buds in perennials. Further, the size of the SAM is constrained by cell-level traits (such as genome size which is known to determine cell size) and developmental/growth form traits such as rosette vs. non-rosette form, shoot lifespan (cyclicity). In this study, we conducted comparative analyses of shoot apical meristem of a number of plants differing in their clonal growth form in order to link the meristem size parameters with other plant trade-offs. We measured both the cell number and the whole SAM size on the cross section. We analysed relationships of these SAM parameters to total leaf area, genome size or cyclicity by examining two congeneric plants differing in these parameters. Shoot tips or developing buds were collected in the spring. SAM was removed under the dissecting microscope from fresh plants. The dissected tissue was fixed in FPA fixative. After rehydration, the meristems were stained by 5 mg/ml propidium iodide in 0.1 M L-arginine pH 12.4 and viewed with an argon laser (excitation 514 nm) using the Zeiss confocal LSM 5 microscope. The photos were than evaluated by the LSM image browser. Preliminary results have showed significant differences between studied plants.

HABITATS AND PERFORMANCE OF *CALLA PALUSTRIS* L. IN THE TŘEBOŇ BASIN BIOSPHERE RESERVE, CZECH REPUBLIC

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Calla palustris (C.p.) is a clonal pleustohelophyte (sensu Hejný et al. 1998) of the family Araceae, mostly occurring in peaty wetlands of the northern temperate zone. It is potentially threatened by human interventions in its habitats, especially by lowering of water table in wetlands. Unresolved remain this species' responses to increased both external and internal mineral nutrient loading of its habitats and to different levels of incoming solar irradiance. The aims of this study therefore were as follows: (a) Assessment of environmental conditions in 5 different habitats of C p.in the Třeboň Basin Biosphere Reserve and of the feedback effect of C.p. on these conditions. (b) Experimental assessment of the effects of 3 different levels of mineral nutrient (N,P,K) supply on the dry matter production and several biometric characteristics of *C.p*. plants. (c) Assessment of the growth and several morphological features of *C.p.* plants in response to 3 levels of relative irradiance in a common garden experiment. The results of these three studies may be summarized as follows: Dense cover by floating *C.p.* plants brings about weak irradiance within the entire vertical profile of a water body. This situation in turn results in relatively low water temperature, oxygen concentration and pH immediately beneath the *C.p.* cover. (b) *C.p.* plants responded positively to increased mineral nutrient supply. Therefore they can thrive even in meso- to eutrophic wetland habitats. This adaptation of *C.p.* plants is possibly connected with their demand for a slight to moderate dystrophy, i.e., presence of chelating humic substances in their habitats. (c) Vegetative growth and spreading of *C.p.* clones responded positively to shading whereas their flowering and successive fruiting were most frequent under conditions of incident full solar irradiance. These results indicate that shallow ditches or pools with slowly flowing water sufficiently loaded with mineral nutrients, occurring in forests with a loose canopy probably represent highly suitable sites for sustainable occurrence and conservation of extensive *C.p.* clones as well as for sexual reproduction of *C.p.* plants.

AN EFFECTIVE PCR-BASED METHOD FOR GENOME-WIDE SNP GENOTYPING USING NGS PLATFORM

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Restriction-enzyme-based next-generation sequencing (NGS) methods have revolutionized marker-assisted genetic studies; however, the use of restriction enzymes has limited its widespread adoption, especially in field samples with low-quality DNA and/or small quantities of DNA. Here, we developed a PCR-based procedure to construct reduced representation libraries without restriction-enzyme digestion steps, representing de novo single nucleotide polymorphism discovery, and its genotyping using next-generation sequencing. Using multiplexed PCR primers, thousands of genome-wide regions were effectively amplified from a wide variety of genomes without prior genetic information. We demonstrate reproducibility of genotyping by checking its applicability for clone (individual) identification and its applicability in a wide variety of species by checking standard population genetic analysis. This approach, called MIG-seq, is applicable to a wide range of marker-assisted genetic studies, especially for medium-scale studies based on less than 1000 markers in ecological, phylogeographic, and conservation genetics, including quick identification of clones.

THE EVOLUTION OF MASS FLOWERING IN BAMBOOS: SEVERE INTRA-GENET COMPETITION SHORTENS FLOWERING TIME

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Bamboos are monocarpic clonal plants that undergo mass flowering after the long period of rhizomatous clonal growth. It has been documented that the time to flowering after germination (flowering interval) shows a geographic pattern from tropical (short interval) to temperate (long interval) region, and is positively correlated with the length of rhizome. To explore the impact of rhizome length on the evolution of flowering interval in bamboos, we developed a spatially explicit simulation model. We focused on the role of spatial arrangement of ramets mediated by rhizome length, and intra-genet competition over space. Plants with long rhizome can establish their clonal offspring far from the origin, but plants with short rhizome make clumped spatial structure. We demonstrate that longer rhizome drives longer flowering time as the evolutionary consequence. This result should be caused by intra-genet competition mediated by rhizome length. If rhizomes are short, population growth rate through clonal growth is reduced due to severe intra-genet competition over space, which favoured short flowering interval. Longer rhizomes, on the other hand, mitigate the intra-genet competition, and hence longer period of clonal growth (flowering interval) can be realized.

CLONAL FRAGMENTATION ALTERS COMPETITION BETWEEN TWO FLOATING PLANTS

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Floating clonal plants are important components of some aquatic ecosystems, and some of these species can form extensive monocultures, implying high competitive ability. Two such species, *Pistia stratiotes* and *Eichhornia crassipes*, have stolons that are easily broken by physical disturbance, suggesting that clonal fragmentation might play a role in competition, since integration between connected ramets is well known to affect their individual and combined performance. To investigate the effect of clonal fragmentation on competitive interactions between *P. stratiotes* and *E. crassipes*, we manipulated plant densities and connection between ramets in a greenhouse experiment. In the absence of fragmentation, interspecific competition decreased the growth in mass and number of ramets of *P. stratiotes*, and had little effect on *E. crassipes.* Fragmentation enhanced this effect increasing the negative response of *P. stratiotes* to competition but not affecting the response of *E. crassipes*. Results thus showed that fragmentation can shift competitive balance between clonal species. In this case, fragmentation appeared to favour the superior competitor. Tests on additional species could show whether this is general among clonal species.

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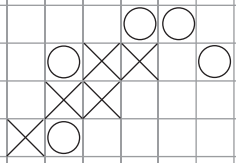

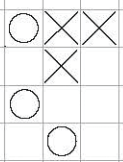

photo: Vítek Latzel