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# COMPARISION OF THE ROLE OF INVASIVE ALIEN PLANTS IN OPEN SAND GRASSLANDS

Summary of Ph.D. thesis

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## 1. Introduction and general overview

The phenomenon of biological invasions, as one of the components of the recently intensifying human-driven global change has become one of the most important economic and environmental problems. According to some calculations biological invasions play the second most important role—after the effects of direct habitat destruction—in mass species extinctions. The economical cost of invasions can be measured in billions of dollars. Although the deliberate or unintentional transport of non-indigenous organisms by man has been accelerating since the age of the great geographical discoveries, the problem of invasions has only been receiving attention by ecologists for the latest few decades. The Anglo-Saxon school of the research of biological invasions, which originate from CHARLES ELTON's seminal work has developed into four main separate branches, that study different aspects and components of the invasion problem. The first main branch tries to answer the question what biological traits enable a plant species to become a successful invader. Up to the present day, these studies have not been able to find principles general and powerful enough to give good predictions. The approach itself, that invasive characterictics can be predicted based only on plant characterictics and neglecting the diversity of the novel enviroments and communities is being more and more often criticised, and it seems that we will never be able to find straightforward and powerful answers. The second branch of invasion research studies what factors make a community invasible. The most popular hypotheses are that plant community diversity, disturbance, and different abiotic factors, first of all available nutrients substantially affect community resistance to invasions. Of these, disturbance seems to be proven to be a relevant factor, but as far as the other factors are concerned, the results are controversial. It seems to be a general problem with these studies that they mostly focus only on the colonisation phase of invasion, and that searching for general "laws" they ignore the specificity of the interaction between the invasive plant an the community. The third main branch studies the impacts of the invasive plants on the invaded community. The research of impacts is driven by practical considerations, and focuses on specific species with permanent success well beyond the colonisation phase and with large impacts. For these reasons the studies of impacts can hardly be connected to the studies of invasibility. The fourth main branch of invasion research studies the opportunities of management and control of invasive plants. This field of studies is rooted in the traditions of the technology-centered agricultural weed control. Today, this field seems to call for a more holistic and integrated approach which focuses not only on separate aspects of the invasion process, but demands the incorporation of the knowledge of the broad historical, landscape, human, community dynamics aspects, and a deeper research into the specificity of the interaction between the plant and the community. In the so far ignored East-European trend of invasion research, which is rooted in different traditions, an integrated and holistic approach has been synthetised in the works by JANUS BOGDAŃ FALIŃSKI. The research of the Polish scholar integrate the knowledge of community dynamics, historical aspects, human impacts, and the specificity of community-plant interactions, and views plant invasion as a process. He also developed a consistent conception and terminology which is able to connect the different aspects of the invasion with the broader fields of vegetation science. As the practical aspects of the invasion problem grow, it is desirable that the more integrated and holistic approaches building bottom-up from detailed case studies gain more emphasis in the research into plant invasions.

## 2. Aims of the study and hypotheses

The general aim of the present study is to give as far as possible a general and complete synfenobiological description of the interaction between the most important non-woody invasive plants and the open sand grassland vegetation of the Kiskunság region, Hungary, with special regard to the nature conservation problems. The most relevant questions are the following:

- What conditions (in terms of community state and external factors) are favourable for the colonization of the invaders?
- What conditions enable the persistence of the invaders, in which (dynamically linked) coenostates, under what conditions, how long an invasive plant persists or disappears?
- What conditions enable an invader to become dominant?

- What kinds of relationships can be detected between the alien and native plants?
- What is the role of the alien species in the community structure?
- What is the impact of the alien species on the vegetation: what kinds of coenostates develop in the presence of the invader?
- What is the landscape pattern in space and time of the invader in the vegetation mosaic?
- How do human activities affect invasion?
- What kinds of nature conservation values are threatened by the alien species, how can the problems be managed?

Obviously, the above questions can be answered by long term observations and experiments carried on a variety of scales. In the recent study I will only try to present a methodological attempt to approach the problem. For the observations I choose a diverse sand grassland area that might represent the main types of the dry open sandy vegetation types of the Kiskunság region. The study focuses on the five most important non-woody invasive plants. With mapping, and in some cases with repeated mapping of the distribution of the species I attempted to explore the preferences of the invaders to the different vegetation types, and the dynamics of their distribution pattern and abundance. The stands of the three most important species representing the most characteristic invaded vegetation types were subject to more detailed examinations. With the examination of these stands my aim was to explore whether any substantial change (in terms of species loss or appearance of new species alien to the original vegetation) can be detected in the sand grassland vegetation.

The second, more specific aim was to test hypotheses regarding the role of the invasive species in community structure. I tried to pose an alternative approach to the wide-spread studies which simplify the question of the interaction between community structure and invasion to the effect of diversity to invasion success. I measured the community structure characteristics in terms of the information theory measures developed by PÁL JUHÁSZ-NAGY in the stands of the three most important invasive species. The hypotheses were the following:

- The measures of spatial organization are lower in the pioneer stands of the invaders than in stands with more mature vegetation.
- The stands with more mature vegetation are less patchy, the maximal diversity of species combinations manifest in finer spatial scales.
- In community types less favourable for the invader the measure of spatial determination of the alien species is higher (its appearance is more constrained to specific species-combinations) than in community types more favourable.
- The greater number of significant associations between the invader and the original species indicates higher transformer ability of the alien species.

## 3. Materials and methods

### 3.1. Study area and vegetation

The studies were conducted in a sand grassland area (part of the Kiskunság National Park) in the Kiskunság region, Hungary, near the village Fülöpháza. The area is of very high conservation value, its vegetation, geology, history has been subject to a lot of scientific investigations. The habitat is characterised by very poor soil conditions (sandy skeleton soil) and dry climate with continental characterictics. The vegetation is dominated by the different types of the Pannonian open perennial sand grassland (Festucetum vaginatae) with patches of the dinamically linked open annual grassland (Brometum tectorum) characteristic of degraded areas. Between the sand grassland areas ploughlands and old-fields (former ploughlands and vineyards) of different ages can be found.

3.2. Invasive species studied

Several alien plant species at different stages of invasion can be found in the area. For the recent study I choose the five most important non-woody species, which represent a wide variety of life forms, reproductive strategies and other biological traits. Four of the invasive species (*Conyza canadensis*, *Cenchrus incertus, Asclepias syriaca, Ambrosia artemisiifolia*) are alien to Hungary (and to Europe as well). Their invasion is considered to be linked to disturbance and the degradation of the original vegetation. The fifth invader, *Cleistogenes serotina* is native to the hilly regions of Hungary, but it appeared in the Kiskunság region in the middle of the 20$^{th}$ century. Its invasion started in the last few decades in the area. According to previous studies *Cleistogenes* preferably invades non-degraded semi-natural vegetation types.

3.3. Sampling methods

3.3.1. Mapping

The distribution and abundance of the species (with the exception of *Cleistogenes serotina*) was mapped in an area of cca. 50 hectares. The abundance of the species was mapped in the field and was documented in 12.5 m × 12.5 m units in a regular grid. The grid consists of 3489 cell units. Mapping of *Asclepias syriaca* vas repeated every year until 2003, and its stems were counted in all stands. Distribution of *Cenchrus incertus* was re-mapped in 2003. Detailed mapping was not conducted after 1999 in the case of the other species, but I followed the change of their distribution and abundance with attention each year.

3.3.2. Sampling of the stands of the invasive species

Stands representing the different dynamic states of the characteristic sand grassland vegetation types invaded by each of three invasive species (*Cleistogenes serotina*, *Cenchrus incertus*, *Asclepias syriaca*) were chosen for detailed study. 10 stands invaded by *Cleistogenes*, 7 stands invaded by *Asclepias*, and 6 stands invaded by *Cenchrus* were sampled (as one of the stands was invaded by both *Asclepias* and *Cenchrus*, the total number of them is 22). In each stand, a circular transect of 1030 5×5 cm microquadrats was placed. Presence data for each species found in the microquadrats was documented.

3.2. Data analysis

3.2.1. Analysis of the distribution maps

Only the 1999 data of *Conyza canadensis* and *Cenchrus incertus* were suitable for detailed qualitative analyses. The distribution maps were compared to the vegetation map (made by ISTVÁN BAGI in 1990) which was digitalized to the resolution of the grid of 12.5 m × 12.5 m units. Based on the presence-absence data of the two species I conducted test of independence in order to determine the preference of the invaders to the different vegetation types. In the case of *Conyza* I also examined how the abundance of the alien species is related to the different vegetation types, and also how the invasibility of the vegetation types is affected by the neighbourhood vegetation.

Without conducting qualitative analysis I also examined how the distribution of the invaders changed between 1999 and 2003, and also that whether the distribution of the species is related to the dirt roads crossing the mapped area.

3.2.2. Coenological investigation of the stands of the invasive species

The coenological character and relationships of the different stands were analysed using the relative frequency data detected in the transects. The different species were grouped on the basis of their coenotaxonomical characteristics (according to the classification in the Hungarian coenological literature). The stands were compared on the basis of the pooled relative frequencies of the different coenotaxonomical groups. The relationships of the different stands were analyzed by multivariate methods. In order to avoid trivial results, frequencies of the invasive species were not used in the

calculations. Hierarchical classification was conducted using Euclidean distance and WARD's method. PCoA ordination was conducted using both JACCARD's index and Euclidean distance.

3.2.3. Microcoenological analysis

The community-structure characteristics were analysed using PÁL JUHÁSZ NAGY's information theory based methodology. Only species with more than 1.5 % were used in the analyses. Overall spatial organization in the community was measured by the maximum value of associatum, species combination diversity by the maximum value of florula diversity. The spatial scales at which the maximum values of the above two measures were detected were also used to characterize the organization of the communities. The overall spatial dependence of the invasive species was measured using the maximum value of complete association, and the quotient of complete associaton and entropy of the species at the smallest (5×5 cm) scale. The significance of the above measures was calculated using two randomization types, complete randomization and random shift. The number of random simulations was 2000 in all cases.

The pairwise association between the invaders and the other species was analysed in the 5–40 cm interval. The number of species with which significant associatton was detected at the 0.05 and 0.01 level, respectively was pooled. The p-values were calculated using 2000 randomisations (random shift).

## 4. Results and discussion

4.1. Results of the mapping

I demonstrated, that the the annual sand grassland (Brometum tectorum community) is less resistant to the invasion by *Conyza canadensis*, and the *Fumana procumbens* type of the open perennial sand grassland (Festucetum vaginatae fumanetosum) is less invasible. The other three types (typicum, stipetosum, salicetosum) of the perennial sand grassland are also quite resistant, but in the vegetation type dominated by *Cleistogenes serotina* the occurence of *Conyza* is higher than expected. The resistance of the different vegetation types seems to be modified by the neighbouring vegetation. This phenomenon is most remarkable in the case of the *Salix rosmariniifolia* type of the perennial grassland (Festucetum vaginatae salicetosum), which is very resistant when the neighbouring vegetation is of the same type, while in the case when any of the neighbouring cells is of a different kind of vegetation, the probability of the occurence of the invader becomes much higher. The abundance and overall distribution of *Conyza* greatly varies from year to year. Its invasion seems not to be connected to dirt roads.

*Cenchrus incertus* preferably invades dirt roads. In 1999 it had several stands in the intact grasslands, but they have almost completely disappeared by 2003 (at the same time the road populations remained constant). The test of independence did not demonstrate any difference between the resistance of the different vegetation types.

*Ambrosia artemisiifolia* was found almost exlusively on the dirt roads.

*Asclepias syriaca* mainly occurs near or in the deeper depressions between the sand dunes. The number and size of its stands showed a continous increase between 1999 and 2003. *Asclepias* does not occur in the dirt roads.

In general, it can be stated that each vegetation type in the area is susceptible to invasion by one or more of the species examined. There is no clear relation between the species' biological traits and the type of distribution and preference.

4.2. Results of the coenological analyses

The sampled stands represent different types, successional and degradation states of the sand grassland vegetation. Most species are characteristic to the different kinds of open sandy vegetation. Species alien to the original vegetation (except the invaders) do not appear in the stands. The multivariate methods discriminate the pioneer vegetation types of the recently abandoned ploughlands and the annual grassland types from the perennial sand grassland vegetation types. *Cleistogenes* stands with

prerennial vegetation form a compact group in each multivariate analysis. Perennial grassland type stands of *Asclepias* and *Cenchrus* form more or less consistent groups depending on the multivariate method. In general it can be stated, that the original sandy vegetation types are not substantially transformed and can well be recognized in the presence of the alien species, although the stands of the different invaders possess some individual features.

4.3. Results of the microcoenological analyses.

In accordance with our hypotheses, the maximal values of associatum and floral diversity in the stands of *Asclepias* and *Cenchrus* are higher in the more mature stands than in the pioneer ones. In the *Cleistogenes* stands the maxima are rather low with values similar to the pioneer stands of the other two species.
The connection between stand pioneerness and the scale of maximal floral diversity does not show the expected pattern.
The maximum value of total association shows an increasing trend from pioneer to mature stands only in the case of *Cenchrus incertus*. In the case of the quotient of total association and entropy none of the species showed the expected pattern.
The number of significant negative pairwise associations was greatest in the case of *Cleistogenes*, while *Asclepias* had the most positive associations and the less negative.
The controversial results concerning community structure call for the more careful rethinking of the hypotheses and methods.

## 5. Conclusions

The studied invasive plant species seem to not have substantial transformer impact on the essential dynamic processes and structural relations of the open sand grasslands. Invasion of *Cenchrus incertus* and *Ambrosia artemisiifolia* is strongly related to recent disturbances, they do not threaten undisturbed vegetation. *Conyza canadensis* might achieve great dominance in some years, but preferably in degraded vegetation types. In contrast, *Asclepias syriaca* has the ability to slowly spread and maintain permanent populations in seminatural grasslands, but its presence does not seem to hinder the regeneration of the seminatural grasslands on a longer run. The permanence of the species of high conservation value seems also not to be problematic in the stands of *Cleistogenes serotina*, but the possible longer effects should be monitored, because this species has the greatest ability to spread in the seminatural vegetation types.

## List of publications related to the thesis

*Articles:*

SZIGETVÁRI, CS. (1999): Az adventív átoktüske (Cenchrus incertus M. A. Curtis) helyzete a fülöpházi természetközeli homokgyepekben. – Kitaibelia **4**: 341-342.

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SZIGETVÁRI, CS. (2002): Az invazív késeiperje, Cleistogenes serotina (L.) Keng. Szerepe nyílt homokgyepek társulásszervezôdésében. – Kitaibelia **7**: 119-139.

SZIGETVÁRI, CS. (2002): Distribution and phytosociological relations of two introduced plant species in an open sand grassland area in the Great Hungarian Plain. – Acta Botanica Hungarica **44**: 163–183.

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*Abstracts*:

SZIGETVÁRI, CS. (1999-2000): Az átoktüske (Cenchrus incertus) elterjedtsége és társulásviszonyai egy homoki élőhelymozaikban. – Botanikai Közlemények **86-87**: 250 - 250.

SZIGETVÁRI, CS. (1999-2000): Néhány homokgyepi invazív növényfaj elterjedési és társulástani sajátosságai. – Botanikai Közlemények **86-87**: 264 - 264.

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