TEMPORAL PATTERN ANALYSIS – A NEW ALGORITHM FOR DETECTING PATCH SIZE IN PLANT POPULATIONS

Á. Méri and L. Körmöczi

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Abstract. Pattern analysis is one of the most important evaluation methods of population structure and of community assembly rules. Several algorithms have been developed to detect the deviation of spatial arrangement of organisms from random. These algorithms reveal in general the pattern intensity that is estimated by the average size of aggregation patches. It is often important to detect the number and actual size of patches and distinguish from the random appearance of individuals.
We used the framework of python programming language to develop a new algorithm for computing patch size and position along transects. We used a long term data set originating from a dry sand grassland to test the program. The algorithm was designed to process very large data sets, and compute temporal variation of patch size distribution.

Key words: spatial pattern, PYTHON, time series, model

Á. Méri, L. Körmöczi, Department of Ecology, University of Szeged, H-6726 Szeged Közép fasor 52., Hungary

Introduction

Pattern — according to the Oxford English Dictionary — is a regular or discernible form or order in which a series of things occur. We talk about spatial patterns in ecology, if the distribution of the living organisms deviates from random, most frequently in the direction of aggregation. It means that the individuals form groups in space, and this pattern can be examined also in time. The importance of patterns manifests very well in variable fields of ecology. The 'patchiness' of individual species distributions contributes to the community organization and therefore it is of central importance in ecology (Anderson and Neuhauser 2002). To understand the natural processes and structures we need to define the scales at which the pattern occurs (Fortin and Dale 2005) and is the result of the local processes of population interaction and dispersal (Murrel *et al*. 2001). Scale appears in spatial structure, if the non-randomness exhibits a certain periodicity (Dale 1991). These examinations have crucial importance in applied use as well. In the investigation of endangered species or in the examination of the structures of habitats we use different kinds of pattern analysis. The information gained by these methods can be valuable in itself, however it can refer to some kind of background factors as well (Fortin and Dale 2005).

The aim of this study was to find an adequate method for analysing our data set about psammophile grassland populations. It was expected to find temporal changes in the spatial pattern of the certain plant populations.

Materials and methods

The database, sampling methods

The data, used for the analyses and testing derive from sandy grassland in Bugac, belonging to the area of Kiskunsági National Park. A transect with 55 meters length and 1 meter width was established (Körmöczi and Balogh 1990), and the monitoring was carried out three times per year (Körmöczi et al 2009). Seasonal data can be compared in the consecutive years, because the field work took place approximately on the same dates every year. In a line of adjacent quadrats, the presence/absence data (0 or 1 values) of the plant populations were recorded. The size of the quadrats was 25×25 centimeters, which is a widely used size in the case of dry grasslands. It means that a grid of 220×4 cells represents each plant population in each monitoring date. The database can be considered as one dimensional data, because the transect is much longer than wide. The four rows of the grid were treated as four individual series and the mean of the values was counted at the analyses.

Quadrat variance methods

There are many ways of analysing one dimensional spatial data. One group of the widely used methods is based on variance analysis of the adjacent blocks of quadrats (Hill 1973). The sampling method must always be carried out with a contiguous grid of quadrats, where presence/absence data of species are recorded (Dale *et al.* 2002). Considering the properties of our database, in the following we will examine the methods only of the aspect of binary data.

All of the quadrat variance analyses apply the moving split window technique. The essence of this method can be summarized in the following main points (Körmöczi 2005). One dimensional data set is adequate for this technique. In the first step we select the first two adjacent cells, as the two halves of the window (1). Then we record the difference of the values in the cells (2). The next step is moving the window one cell further and calculating the difference. These steps are iterated through the whole transect (3). Reaching the end of the data series we calculate the variance (4). Then we jump back to the first cell, and increase the size of the window (5). Then the steps 1-4 are repeated with this new window size. We can increase the size of the window until the halves reach the half size of the transect.

The result is a variance data for each window size. Plotting these data against block size, we get the variance graphs of the data set. The peaks represent the scale of the pattern. However these methods are unable to distinguish patches and gaps (Guo and Kelly 2004), some of them can separate a smaller and a larger phase (Dale 1999). After analysing artificial and simulated data sets as well, we recognized that this latter feature of the methods is reflected only by the analysis of simulated periodical data. Although there are many detailed description about the quadrat variance methods, the literature of this topic is nearly not exhausted. Further investigations may explore additional features of these methods. For examining them, we transformed the mathematical formulas into executable programs in python programming language.

`TemPA`

Based on our experiences with quadrat variance methods our aim was to create a new algorithm for one dimensional pattern analysis. However we used a transformed version of moving window technique, and the mathematical background is much easier, this method is similar to the quadrat variance analyses.

`TemPA` (***tem****poral* ***p****attern* ***a****nalysis*) is a precise patch size determining algorithm. We can get information about the size and position of each patch. The result is the simplified picture of the transect, containing all the necessary information about the bigger patches, but in a reduced form. It means that the computer records only the minimal information determining the patches. So one patch can be determined with actually two values, the position of the first cell and the extent of the patch. This data coding is widely used in raster based geographical information systems and called run-length coding. Simplifying the information about the data set provides an easier treatment in the followings.

The procedure performed on the data may seem rather difficult, but the gained information is as much as available in the smallest possible extent. We transformed the moving window technique by changing the order of switching and enlargement. First the position of window is set, then the window is increased with one cell in each step. After using all the possible block sizes beginning with the first cell, we shift the position one cell further, and repeat the entire process. We used an undivided window, thus the first block size in each position could be only one cell large. For practical reason the starting window size was three cells. Detection of a plant in a single cell can not be considered as a patch, thus there is no meaning of investigating under three cells extent. The maximum window size is equal to the total size of the transect.

Identification of patches is carried out with a system of variable conditions. These are simple mathematical relations, determining the acceptable number of absences in the currently examined block. The following traits of a potential patch are considered:

- the whole extent of the patch – the actual size of the window
- the first and the last cell of the patch – mus be 1
- one cell before and after the patch – must be 0
- the beginning and the end of the patch (3-4 cells) – sum of presences must be over or equal to 3

the area surrounding the patch (3-4 cells) – sum of presences must be under or equal to 2

For each of these intervals we set a mathematical relation. For instance the first and the last cell of the patch must be 1, or the presences in the surrounding area must be under or equal to 2. The predetermined limits are freely alterable, so are the sizes of the investigated intervals. This alterable structure makes the method flexible, thus we can optimize the parameters to our data set.

At each step of the analysis the computer counts the number of presences in the investigated interval. If the value is out of the threshold value, the process stops, and the analysis of the next potential patch starts. If all the values are within the predetermined limits, the investigated area is considered as a patch, and the requisite information are recorded.

The criteria are previously given by the user and can be optimized for the currently analysed data set. When monitoring rare species with small spatial extent, we are searching for small patches of plants, or individuals. Decreasing the minimum detected patch size to one cell will refine the scale. Common species require investigations on a larger scale. The settings of criteria 4-5 determine the required density in the boundary zone between a patch and a gap. With these options we can set, how clear the border should be. Ignorance of the smaller patches is often useful, avoiding the processing of unnecessary amount of information. During the tests we used an average setting, which is appropriate for a large scale of aggregation types.

Results

The validation of the results is carried out visually. The comparison of the original data and the model, created by the computer is required. Bar charts are proper for this aim (Fig. 1). The diagram represents the original view of the transect and the simplified model, built up from the data recorded by **TemPA**. The representation is very much distorted, thus the entire transect can be plotted onto one single picture. One small column represents one quadrat.

The analysed database contained data about 112 plant species in 24 monitoring dates. Twenty five of these plant species were represented on every occasion, so detailed investigations were performed in the case of these species. Some of them were highly abundant, others were rarely occurring. The optimization of the criteria system was performed based on these results. Working with the final settings the analysis of the 25 plants was carried out.

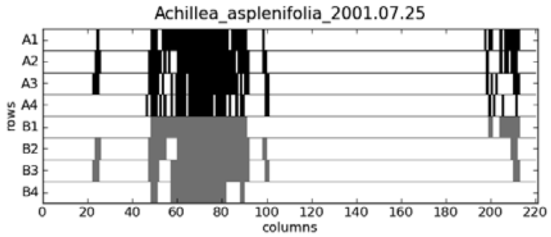

Fig1. The distribution of *Achillea asplenifolia* on the 25th of July 2005. The rows marked with A represent the real distribution, and the ones marked with B are the interpretation of the model built up by the computer. One column on the bar chart represents one quadrat.

After controlling the effectiveness of **TemPA** with the bar charts representing the distribution of each species, the temporal analyses were performed. This means a single line plot for each species, represented on Fig. 2. The lines follow the temporal trends very sensitively due to the punctual patch size detection. Whether counting the average patch size, or using the maximum patch size for the description of the distribution, depends on the user's demand. During the analyses we used the maximum patch size, and counted the mean of the 4 rows of data tables.

In the case of species with very big changes in seasonal distribution, we can represent the seasonal data with 3 different lines (Fig. 3).

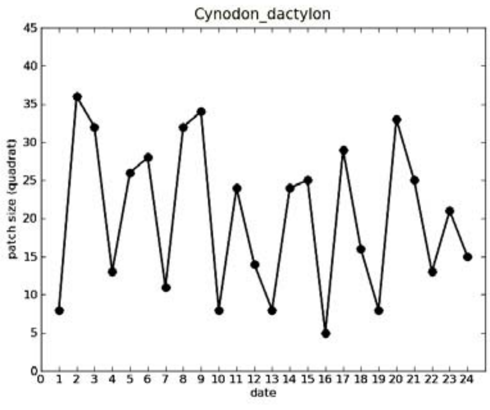

Fig 2. The temporal changes of the patch size of Cynodon dactylon. Each monitoring date got a number, simplifying the visualization. Patch size means in this case the size of the biggest patch.

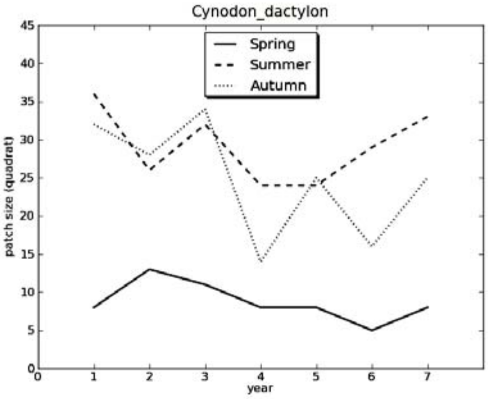

Fig 3. The annual changes of the patch size in the case of Cynodon dactylon. The same values are presented then in Fig 2. Here the seasonal data are plotted separately.

Discussion

Several kinds of methods, analysing one dimensional spatial data are currently available (Dale 2005). The literature, investigating the properties of these methods is comprehensive (Dale 2005, Hill 1973, Goodall 1974, Guo and Kelly 2004, Rosenberg 2001). However there are still undeveloped parts of the methodology of detecting spatial pattern. Our aim was the development of a concrete patch size detecting algorithm. One of the most important factors was the automation of the analysis, permitting of the processing of large amounts of data.

The algorithm, used in **TemPA** is a flexible application, written in python programming language. The properties of the patch size detection are highly modifiable, thus the user can easily form the method to the adequate criteria. The system of conditions provides the possibility of optimization for the user's needs. Without a graphical interface the method and the printed results are freely adjustable. Getting punctual information, we can perform a detailed investigation about the transect not only in space, but in time as well. The available information include the number and the size of the patches and the positioning of each.

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References

Anderson, K. and Neuhauser, C. (2002): Patterns in spatial simulations—are they real? — Ecological Modelling, 155, 19-30

Dale, M. R. T. and Blundon, D. J. (1991): Quadrat covariance analysis and the scales of interspecific association during primary succession – Journal of Vegetation Science 2: 103-112

Dale, M. R. T., Dixon, Ph., Fortin, M.-J., Legendre, P., Myers, D. E. and Rosenberg, M. S. (2002): Conceptual and mathematical relationships among methods for spatial analysis. — Ecography 25: 558-577

Fortin, M.-J. and Dale, M. R. T. (2005): Spatial Analysis, A guide for ecologists. — Cambridge University Press, New York

Goodall, D. W. (1974): A new method for the analysis of spatial pattern by the random pairing of quadrats. — Vegetatio 29: 135-146

Guo, Q. and Kelly, M. (2004): Interpretation of scale in paired quadrat variance methods. — Journal of Vegetation Science 15: 763-770

Hill, M. O. (1973): Diversity and Evenness: A Unifying Notation and Its Consequences. — Ecology 45: 427-432

Körmöczi L. (2005): On the sensitivity and significance test for vegetation boundary detection – Community Ecology 6(1): 75-81

Körmöczi, L. and Balogh, A. (1990): The analysis of pattern change in a Hungarian sandy grassland. — In: Krahulec, F., Agnew, A. D. Q., Agnew, S. and Willems, J. H. (eds): Spatial processes in plant communities. pp. 49-58.

Körmöczi, L., Margóczi, K. and Zalatnai, M. (2009): Kiskunsági homoki gyep hosszú távú állományszerkezet-változása. — In: Gallé, L. (ed.): Entomológia: kutatás, szemléletformálás, ismeretterjesztés. Szeged, 2009. pp. 91-106.

Murrell, D.J., Purves, D.W. and Law, R. (2001): Uniting pattern and process in plant ecology. — TREE 16, 529-530

Rosenberg, M. S. (2001): PASSAGE. Pattern Analysis, Spatial Statistics, and Geographic Exegesis. Version 1.0 — Beta documentation. Department of Biology, Arizona State University, Tempe, AZ.

Appendix
Source code of TemPA:

```
import cPickle
import pylab as plab
import numpy as np
from pylab import *

f1=open("data.dat", "r")
f2=open("dates.dat", "r")
f3=open("names.dat", "r")
adat=cPickle.load(f1)
dates=cPickle.load(f2)
names=cPickle.load(f3)
adatarray=np.array(adat)

year=8
year=year-1
plant=0
print dates.get(year)
print names.get(plant)

for k in range(0,4):
  a=adat[year][plant][k]
  n=220
  s=[]
  h=[]
  p=[]
  l=[]
  w=[]
  de=0
  woo=[]
  for i in range(0,n-3):   #position
   q=0
   for r in range(2,n-i+1): #window size
    v=[]
    x1=[]
    x2=[]
    x3=[]
    x4=[]
    t=0
    q=0
    g=[]
    no=0
    nu=0
    el=1
    veg=0
    for j in range(i,i+r):
     v.append(a[j])
     t=(sum(v))
    if (t>=0.85): #terms
     el=a[i]
     veg=a[i+r-1]
     if (i+r==n-1):
      no=0
```

```
      nu=0
     if (i+r<=n-2):     #cell before/after the patch
      nu=a[i+r]
     if (i>=1):
      no=a[i-1]
     if r<10:
      x1=[4]
      x2=[4]
      x3=[0]
      x4=[0]
     if r>=10:
      for y1 in range(i+r-3,i+r): #last 4 cels
       x1.append(a[y1])
      for y2 in range(i,i+3):  #first 4 cels
       x2.append(a[y2])
      if (i+r<=n-4):
       for y3 in range(i+r,i+r+3): #4 cels after the patch
        x3.append(a[y3])
      if (i>=4):
       for y4 in range(i-4,i-1):  #4 cels before the patch
        x4.append(a[y4])
      if (i+r>n-4) and (i+r<n-1):    #end of patch
       for y3 in range(i+r,n):
        x3.append(a[y3])
      if (i<4) and (i>1):       #beginning of patch
       for y4 in range(0,i+1):
        x4.append(a[y4])
      if (i+r>=n-1):
       x3=[0]
      if (i<=1):
       x4=[0]
    if ((sum(x1))>=2) and ((sum(x2))>=1)and ((sum(x3))<=1) and
((sum(x4))<=1)and (el==1) and (veg==1):
     q=t
     if (t>=(0.87*r)):
      g.append(q)
      g.insert(1,r)
      g.insert(2,i)
      g.insert(3,i+r-1)
      h.append(g)

  for c in h:
   p.append(c[2])
  for e in range(len(p)):
   if (p[e]>(p[e-1]+4)) or (e==(len(p)-1)):
    b=de
    de= p.index(p[e])
    w= h[b:de]
    s=[]
    l=[]
    we=[]
    fe=[]
    ba=0
    femax=0
    for f in w:
```

```
 s.append(f[0])
 if (s!=[]):
  ba=max(s)
for z in range(len(s)):
 if (s[z]==ba):
  we.append(w[z])
for ii in we:
 fe.append(ii[1])
 if (fe!=0):
  femax=min(fe)
for y in range(len(fe)):
 if (fe[y]==femax):
  print we[y]
```

TISCIA 38, 11-18

OCCURRENCE OF TRUE FROGS (RANIDAE L.) IN THE REGION OF SZEGED AS RELATED TO AQUATIC HABITAT PARAMETERS

G. Solomampianina and N. Molnár

Solomampianina, G and Molnár, N (2011): Occurrence of True Frogs (Ranidae L.) in the region of Szeged as related to aquatic habitat parameters. — *Tiscia 38, 11-18.*

Abstract. If there is any kind of change in their habitats, it is always indicated by the reaction of the amphibians. Their presence is a good indicator of environmental and ecological health. The effect of pond temperature, water depth, pH, predators and vegetation inside the ponds were investigated during one breeding period in seven different types of habitats. We also carried out a visual (capture and spawn monitoring) and an acoustic (call monitoring) method in every study site. Our goal was to ascertain which parameter of the ones mentioned above affects the True frogs the best and to identify how many species of anuran occur around Szeged. Our results show that water temperature and predators have a positive correlation with the occurring True frogs. Furthermore, pH does not seem to be an influential parameter since the measured values ranged between 7,13-8,98. As far as the faunistic study is concerned, 9 of the 10 existing anuran species in the lower Tisza region were identified and the occurrence of the 10th's one was also theoretically proved.

Keywords: correlation, True Frogs, habitat parameters, ecological health, pond temperature, predators.

G. Solomampianina, N. Molnár, Department of Ecology, University of Szeged, H-6726 Szeged Közép fasor 52., Hungary

Introduction

Due to their skin, anurans are very sensitive to any change occurring to their habitat; therefore their presence in wetlands is a good indicator of environmental and ecological health (Piotr 2006). Nevertheless, Hungarian scientific herpetological literature does not mention any ecological study on the frogs of the region of Szeged. The last potamo-biological study on the Lower Tisza's herpetofauna was made by Miklós Marián in 1960 during which he also took some ecological facts into consideration. This museologist identified 8 anuran species in the region of Szeged. Meanwhile, the frogs' habitats have seen many changes like road constructions, agriculture and the different kinds of pollution of the river Tisza. These facts made us plan and carry out an ecological study on the true frogs' population in Szeged and its neighbourhood. The investigation took place in 7 different types of aquatic habitats: Hattyas (oxbow), Nagyfa (marsh), Gyálarét (clay pits), Nagyszéksós (saline lake), Zsombó (fen and an artificial pond) and Atka (fishpond).

Our research efforts focused on the family of True frogs. On the Great Hungarian Plain this family falls into two groups: the often aquatic, noisy Water or Green Frogs (3 species) and the frequently more terrestrial, quieter voiced Brown Frogs (2 species) (Arnold and Ovenden 2004). As amphibians, Ranids have aquatic and terrestrial habitats. The choice of the aquatic habitat in our study is due to the fact that every frog needs water during the breeding season; therefore it is the best place to monitor the occurring species. Moreover, the Green Frogs are strictly aquatic species hence water body is the only habitat where they can be found (Dely 1976). In the light of these, in our study we aimed to answer the following questions: which aquatic habitat parameters correlate the best with the occurrence of the true frogs? Is there any change in the number of species compared to the results of Miklós Marián (Marián 1963)? Five habitat parameters were chosen to answer the first question and we carried out our investigation in seven study sites that are located far from each other to get the optimum number of species around Szeged. We grouped the parameters into physicochemical (water temperature, pH and depth) and biological (abundance of potential frog predators and the percentage of emergent aquatic vegetation cover).

Among the mentioned parameters, temperature is one of the environmental factors that strongly affects the development and growth of poikilothermic organisms (Orizaola *et al*. 2010). In ectotherms, low temperature reduces growth and development rates (Gillooly and Dodson 2000, Angilletta *et al*. 2004). Thus in cold-blooded species with complex life cycles, temperature experienced during early development can influence individual body condition and fitness and have a strong effect on later performance. One of our study sites is proved to be strongly polluted that is why the water acidity (pH) is taken into consideration in our study (Györffy 2005). Field studies on amphibian abundance and species diversity have shown a clear correlation between the acidification of breeding ponds and the decline of amphibian populations (Glos *et al*. 2003). Although for anurans the critical pH value is 4,5-5 (Horne and Dunson 1994, Tattersall *et al*. 1996), the higher values may also cause different abnormalities during the metamorphosis, thus that may decrease species' abundance. As for the last parameter, many studies have already shown that anurans have several predators (Kats *et al*. 1988, Wilson *et al*. 2005, Hossie and Murray 2010). Predation is an important factor in ecology and frogs are regularly fed upon by great variety of predators (Glaw and Vences 2007). According to their life cycle, the following species are all potential predators of frogs: European perch (*Perca fluviatilis* L.) consume spawns (Pintér 2002), dragonfly and diving beetle nymphs peck tadpoles' extremities (Ohba 2009, Anssi and Kujasalo 1999), finally pike (*Esox lucius* L.), asp (*Aspius aspius* L.) grass snakes (*Natrix natrix* L.), white storks (*Ciconia ciconia* L.) and black-crowned night heron (*Nycticorax nycticorax* L.) all prey on adult frogs (Mark and Tim 2001, Haraszthy 2000). According to the data from the Csongrád County Anglers' Clubs Association, one of the ponds contains some potential anuran predator fishes like pikes (*Esox lucius* L.) and asps (*Aspius aspius* L.) (Petrik 2010).

Materials and methods

Study sites

We chose two study sites in the Northern (Atka, Nagyfa), Southern (Gyálarét, Hattyas) and three study sites in the Western (Zsombó, Nagyszéksós) region from Szeged, out of which 3 (Algyő, Nagyfa and Gyálarét) are located next to the Tisza River (Table 1). Maps of the sites with the indication of sampling plots are listed in the Appendix.

Table 1. Study sites and their geographical parameters

Sites	Area (Hectares)	GPS coordinates
Atka	7,5	N 46°23'93" E 20°10'47"
Nagyfa	4	N 46°17'52" E 20°15'14"
Gyálarét	2,5	N 46°21'41" E 20°12'13"
Hattyas	4	N 46°13'40" E 20°6'9"
Zsombó (art. pond)	0,5	N 46°18'53" E 19°59'3"
Zsombó (fen)	1	N 46°18'54" E19°59'17"
Nagyszéksós	105	N 46°12'41" E 19°57'7"

Sampling methods

The samplings were performed from the end of February until the first half of May of the year 2010. During this period we completed 4 sampling in each study site and every single sampling was divided into two: diurnal and nocturnal part. Around every single aquatic habitat we regularly chose ten sites that are more frequented by the Green frogs. For the sampling we placed 5×5 meters quadrates in every single chosen site directly next to the aquatic habitats. To avoid recapturing the same specimen, every quadrate was at the minimum distance of 10 meters from each other. Two methods were used to collect frogs from the quadrates: catching manually and fishing out (especially the water frogs) with scoop net. The collected frogs were morphologically identified, counted and then released.

To determine the presence of Brown frogs we used egg masses' monitoring. But for the data set we counted only the captured adult frogs. Acoustic method was also used to check the presence of the other species that do not belong to the family Ranidae, still, this time we only counted the visually and morphologically identified species.

Parameters

Water depth influences the water temperature and also the success of eggs to get hatched for those frogs that lay their eggs on floating plants (for example brown frogs). The mentioned variable was measured with a 10-meter-long tape measure. We measured water depth five times in every sampling site, which means that 50 data per measurement were collected in every single aquatic habitat. Measuring was repeated four times during the field work. The water temperatures were measured with iButton® data loggers placed to the aquatic habitat from the end of February until the first half of May. In every study site we put one data logger that was set up to record the water temperature in every 40 minutes. Thus we could get as many data as possible and due to their capacity we only had to reset the data loggers once. For the data analyses we considered the recorded temperatures from four days around the sampling (three days before – which can influence the appearance of species – and the day of sampling). The water acidity was measured with Voltcraft® pH-100 ATC pH-meter. During our field works we measured pH-values on each of the ten sampling sites three times, in the course of the second, third and fourth samplings. In the first sampling we have not had the appropriate pH-meter at our disposal yet. As for the potential anuran predators, we only mentioned those species that we have found in the field sites during the surveys done in 2009 and 2010. We added them together and grouped them into 4 categories: bug's larvae, fishes, grass snakes and birds. Then we got 9 species of predators. For the statistical data processing we numbered the group of predators that we found in the study sites (Table 2).

Table 2. Classification of the occurring predators for the statistical data processing

Number of the predator's group	Occurring predator
1	if only one kind of predators occurs
2	if two kinds of predators occur
3	if three kinds of predators occur
4	if all kinds of predators occur

Statistical analysis

The correlation between the variables and the occurring frogs was calculated with Microsoft Excel® to get the R- and R^2-values. Then we used the independent one-sample t-test to test the significance of the correlation values calculated. We only had to calculate the degrees of freedom and then adjust them to the desired p-values. As null hypothesis we considered that there is no correlation between the variables and the estimated number of the true frogs' individuals. Consequently null hypothesis was rejected when the observed *t*-value exceeded the tabulated value in the *t*-test table according to the calculated degree of freedom.

Results

Faunistic results show that ten species of anurans mentioned in the Hungarian herpetological scientific literature occur in the regions around Szeged (Puky *et al.* 2005, Vörös 2008, Schäffer and Purger 2005), including Fire-bellied toad (*Bombina bombina* L.), Common spadefoot (*Pelobates fuscus* L.), Common toad (*Bufo bufo* L.), Green toad (*Bufo viridis* L.), Common tree frog (*Hyla arborea* L.), Moor frog (*Rana arvalis* L.), Agile frog (*Rana Dalmatina* L.), Marsh frog (*Pelophylax Ridibundus*) and Edible frog (*Pelophylax* kl. *esculenta* L.). We did not identify the Pool frog (*Pelophylax lessonae* L.) but its presence is theoretically indicated by the Marsh and Edible frogs, since the latter species is an offspring of the interbreeding between Marsh frog and Pool frog (Arnold and Ovenden 2004). Geographically, the region of Szeged belongs to the Hungarian flood plain thus two anuran species – Yellow-bellied toad (*Bombina variegata* L.) and Common frog (*Pelophylax temporaria* L.) – cannot occur in the mentioned region, since they only live in higher (up to 400 m altitudes) habitats (Dely 1967). All ten species occurred in the clay pit of Gyálarét and only three species occurred in the fen in Zsombó (Table 3).

Table 3. Result of the visual method containing the total numbers of counted individuals per species. BOBO: *Bombina bombina* (Fire-bellied toad), PEFU: *Pelobates fuscus* (Common spadefoot), BUBU: *Bufo bufo* (Common toad), BUVR: *Bufo viridis* (Green toad), HYAR: *Hyla arborea* (European tree frog), RARV: *Rana arvalis* (Moor frog), RDAL: *Rana dalmatina* (Agile frog), PRID: *Pelophylax ridibundus* (Marsh frog), PLES: *Pelophylax lessonae* (Pool frog), PESC: *Pelophylax esculenta* (Edible Frog)

	Atka	Gyálarét	Hattyas	Nagyfa	Nagyszéksós tó	Zsombó artificial pond	Zsombó fen
BOBO	0	11	1	16	58	4	3
PEFU	0	4	0	0	10	9	0
BUBU	0	11	0	0	0	0	0
BUVR	0	4	0	4	0	0	0
HYAR	7	17	9	15	12	14	25
RARV	0	2	0	17	0	0	0
RDAL	0	5	0	20	0	0	0
PRID	51	53	17	31	63	17	2
PLES	0	0	0	0	0	0	0
PESC	47	39	12	21	60	13	0

Correlation between habitat parameters and the occurrence of True Frogs. Due to the Tisza-River, the level of water depth oscillated in those habitats that are in the floodplain and remain mainly constant in the other study sites. There was no significant correlation between the water depth and the occurring True Frogs. However, we noticed that water level oscillation harms the frogs' development since the low tides dry Ranid eggs. As for the water temperature, the obtained average values were between 10 and 15°C. Nagyfa's marsh was the coldest (average 10°C) and Atka's fishpond was the warmest (average 15°C). Moreover, we have noticed that the aquatic habitat's vegetation cover has an important role in warming up the water, which means that those habitats which are more covered by vegetations (i.e. trees) were colder than those that have less vegetation cover. Considering the average temperature registered four days around the sampling (three days before and the day of the sampling), our result shows that temperature has significant correlation with the occurrence of True Frogs (Fig. 1).

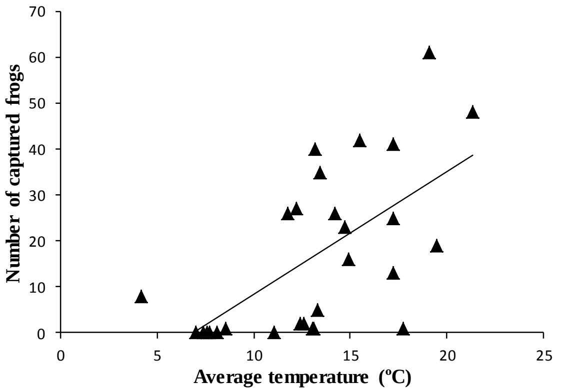


Fig. 1. Correlation between the number of captured True Frogs in each sampling and the registered water temperatures four days around the samplings (three days before the day of the sampling, y = 2,6636x - 18,231; R² = 0,3983)

We still have to clear whether the significant correlation is represented in every single aquatic habitat or not (Table 4). Table 4 shows that we got significant correlations in three study sites. This means that the warmer the aquatic habitats get, the more frogs occur. Moreover, the rise of water temperature is one of the factors that break the Frogs' hibernation. Finally, the end of hibernation does happen at the same temperature among the Ranids. It would be interesting to make an investigation in the autumn whether or not the True Frogs' occurrence decreases according to the fall of water temperature.

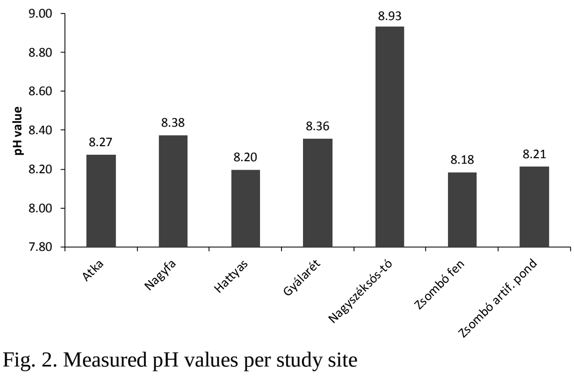


Fig. 2. Measured pH values per study site

Furthermore, we calculated the correlation between pH values from the data of the 7 study sites and the number of the captured frogs (R(exp) = 0,82, R(obs) = 0,31, p = 0,05, N = 32, DF = 22) but the result was not significant.

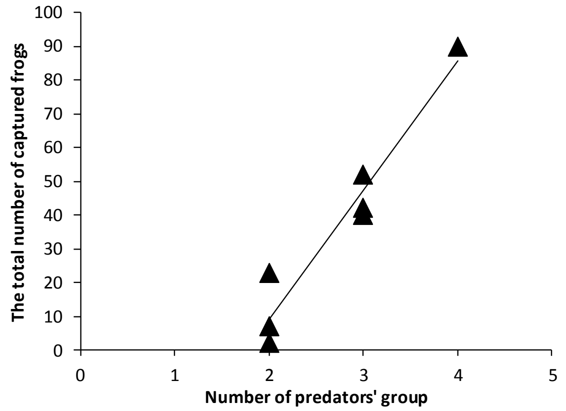


Fig. 3. Correlation between the total numbers of captured frogs in each study site and the number of occurred predators' group (R^2 = 0, 93; N = 7)

Finally, our null hypothesis was rejected regarding the correlation between the occurring predator groups' number and the total number of captured True Frogs (Fig. 3). Furthermore, we analyzed the correlation between the total number of observed predators in each study site and the average number of captured frogs during the four samplings (Fig. 4). The results show that the more True Frogs occurred, the more predators and predators' group we found.

Table 4. Correlation between total number of captured frogs and the average water temperature, where the * is significant at p = 0, 1 and the ** is significant at both p = 0, 1 and p = 0, 05

Study sites	R-values	R^2-values	t_{crt}
Atka	0,86	0,75	2,48
Hattyas	0,92	0,85	3,35*
Gyálarét	0,74	0,55	1,56
Nagyfa	0,95	0,91	4,47**
Nagyszéksós	0,5	0,27	0,83
Zsombó art. pond	0,9	0,81	3,13*
Zsombó fen	0,86	0,74	2,38

Discussion

Compared to the survey made by M. Marián, we have identified two more species (*Pelobates fuscus* L. and *Pelophylax lessonae* L.) in the region of Szeged. According to its habitat, *P. fuscus* typically occurs in light soiled places (Puky et al. 2005), thus its occurrence in the Tisza-River's floodplain is rare.

This can be the reason why M. Marián could not find the mentioned species, since his surveys focused on the Tisza-River's floodplain. The oscillation of water depth seems to have a negative effect on frogs' spawns because the eggs laid on floating parts of plants dry out at low tides, nevertheless this phenomenon can be considered as a part of natural selection that frogs living in those habitats got used to. The phenomenon is common in the aquatic habitats located in the floodplain of the Tisza-River. Furthermore, our study shows that the pH values measured in the study sites are nearly identical which are between 8,18 (the fen in Zsombó) and 8,93 (the saline lake in Nagyszéksós), thus amphibians living in the chosen 7 study sites are not exposed to critical low pH values (pH 4,5 – 5). Although several studies made in Hattyas showed that the aquatic habitat is highly polluted (Györffy 2005), it seems that the pollution is – inter alia – due to the low level of oxygen which leads to the fact that only Green Frogs occur there. Our study shows exclusively the occurrence of Green Frogs in Hattyas; hence further research is still needed to be done in order to prove whether or not the frog species can reproduce in the aquatic habitat mentioned. Certainly we did not find any spawn either tadpole during our field work. As for the water temperature, we noticed that there is correlation between the total number of captured frogs from the whole study sites and the average water temperature.

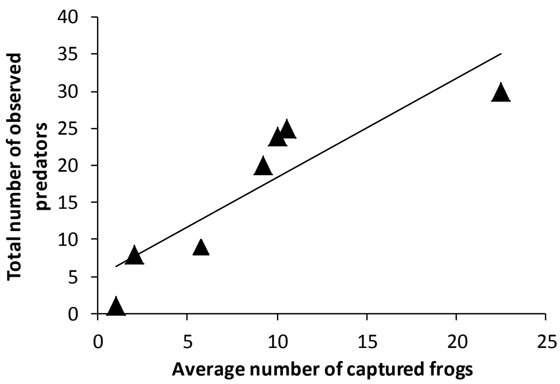


Fig. 4. The correlation between the total number of observed predators in each study site and the average number of captured frogs during the four samplings ($y=1,3342x + 5,0875$; $R^2=0, 7944$)

As far as predators are concerned, our result proves that the presence of predators does not disturb the True Frogs. At first sight, our data does not seem to be reliable since predators decimate the mentioned anurans hence frogs should fear them. Therefore, where there are predators few frogs should occur. But if we take stock of the frogs' physical aptitudes such as the capability of changing the intensity of their skin's colour according to the environment which help them to camouflage and the ability to jump high and quickly and also to swim agily thanks to their strong forelimbs and well webbed toes, we immediately understand why they can live together with their predators. The mentioned abilities reduce predators' success hence they allow the cohabitation of frogs and their predators. As for the predators, it is more remunerative to prey upon frogs where there are more anurans therefore they increase their predatory success.

Acknowledgement

Our sincere thanks go to Prof. Dr. Miguel Vences for his professional guidance and also for the tools he gave us to carry out our field work. This work was supported by the Directorate for Environmental Protection and Water Management of Lower Tisza District (ATI-KTVF 70.331-1-2/2010).

References

Angilletta, M. J., Steury, T. D., Sears, M. W. (2004): Temperature, growth, and body size in ectotherms: fitting pieces of a life-history puzzle. – Integr. Comp. Biol., 44, 498-509.

Anssi L., Kujasalo, J. (1999): Habitat duration, predation risk and phenotypic plasticity in common frog (*Rana temporaria*) tadpoles. – Journal of Animal Ecology, 68,1123-1132.

Arnold, N., Ovenden, D. (2004): Reptiles and amphibians (Britain & Europe). London, Collins, p. 88.

Dely, O. (1967): Amphibian-Amphibia. – Fauna of Hungary (Fauna hungariae), Budapest, Akadémiai kiadó (in Hungarian), 20, 3, 38-81.

Gillooly, J. F., Dodson, S. I. (2000): The relationship of neonate mass and incubation temperature to embryonic development time in a range of animal taxa. – J. Zool. 251, 369-375.

Glos, J., Grafe, T. U., Rödel, M.-O., Linsenmair, K. E. (2003): Geographic Variation in pH Tolerance of Two Populations of the European Common Frog, *Rana temporaria*. – Copeia, 3, 650–656.

Györffy, G. (2005): Gyálai-Holt-Tisza ökológiai vizsgálatának eredményei / Results of the ecological studies in the oxbow-lake of Gyála. – Pálfai I., A II. szegedi holtág-konferencia előadásai, Budapest (in Hungarian), 97-108.

Haraszthy L. (2000): Birds of Hungary. Mezőgazda. Budapest, 15-34.

Horne, M. T., Dunson, W. A. (1994): The interactive effects of low pH, toxic metals, and DOC on a simulated temporary pond community. – Environmental pollution, 89, 155-161.

Hossie T. J., Murray, D. L. (2010): You can't run but you can hide: refuge use in frog tadpoles elicits density-dependent predation by dragonfly larvae. – Oecologia 163, 395-404.

Kats, L. B., Petranka, J. W., Sih, A. (1988): Antipredator defenses and the persistence of amphibian larvae with fishes. – Ecology 69, 1865-1870.

Marián, M. (1960): Adatok a Felső-Tisza herpetofaunájához / Data on the herpetofauna of the Upper Tisza region. – A Móra Ferenc Múzeum Évkönyve, 259-275.

Marián, M. (1963): Közép-Tisza kétéltű és hüllő világa / Amphibians and reptiles of the Middle Tisza region. – Móra Ferenc Múzeum Évkönyve, Szeged (in Hungarian), 207-231.

Mark O., Tim, H. (2001): Reptiles and amphibians. – Panemex-Grafo, Budapest, p. 256.

Glaw, F., Vences, M. (2007): A field guide to the amphibians and reptiles of Madagascar. –Third edition, Vences & Glaw Verlag, p. 48.

Ohba, Sh. (2009): Feeding habits of the diving beetle larvae, *Cybister brevis* Aubé (Coleoptera:Dytiscidae) in Japanese wetlands. – Applied Entomology and Zoology, 44, 447-453.

Orizaola, G., Dahl, E., Laurila, A. (2010): Compensating for delayed hatching across consecutive life-history stages in an amphibian. – Oikos, 119, 980–987.

Pintér, K. (2002): Magyarország halai / Fishes of Hungary. – Akadémiai Kiadó, Budapest, p. 222.

Piotr, T. (2006): Is body size of the water frog *Rana esculenta* complex responding to climate change? – Naturwissenschaften, 93, 110–113.

Puky, M., Schád, P., Szövényi, G. (2005): Magyarország herpetológiai atlasza / Herpetological atlas of Hungary. – Varangy Akció Csoport Egyesület, Budapest, p. 207.

Schäffer, D. A., Purger, J. (2005): A barna ásóbéka (*Pelobates fuscus*) elterjedése Magyarországon / The spreading of european spadefoot (Pelbates fuscus) in Hungary. – Állattani közlemények, 90, 25-39.

Vörös, J. (2008): A vöröshasú unka (*Bombina bombina* Linnaeus, 1761) és a sárgahasú unka (*Bombina variegata* Linnaeus, 1758) elterjedése Magyarországon / The spreading of red bellied toad (*Bombina bombina* Linnaeus, 1761) and yellow bellied toad (*Bombina variegata* Linnaeus, 1758) in Hungary. – Természetvédelmi közlemények, 14, 45-59.

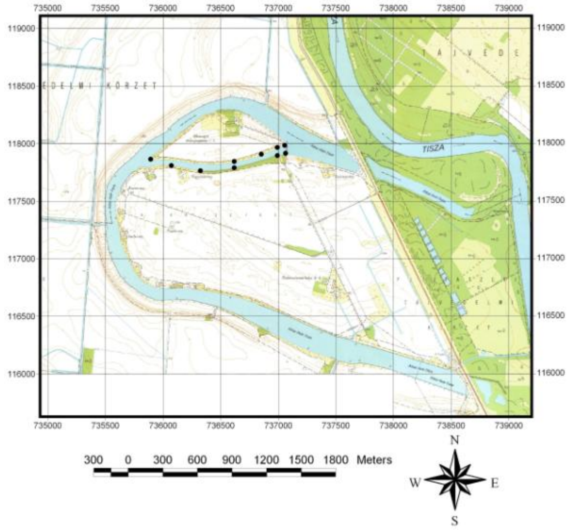
Wilson, R. S., Kraft, P. G., Van Damme, R. (2005): Predator-specific changes in the morphology and swimming performance of larval *Rana lessonae*. – Functional ecology, 19, 238-244.

Tatersall, G. J., Wright, P. A. (1996): The Effects of Ambient pH on Nitrogen Excretion in Early Life Stages of the American Toad (*Bufo americanus*). – Comp. Biochem. Physiol.,113A, 369-374.

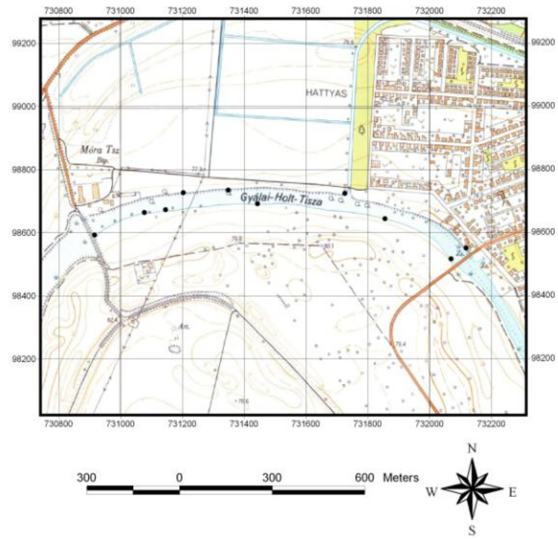
Petrik, O. (2010): http://www.horgaszcsmszov.hu/ (23rd June 2010).

Appendix

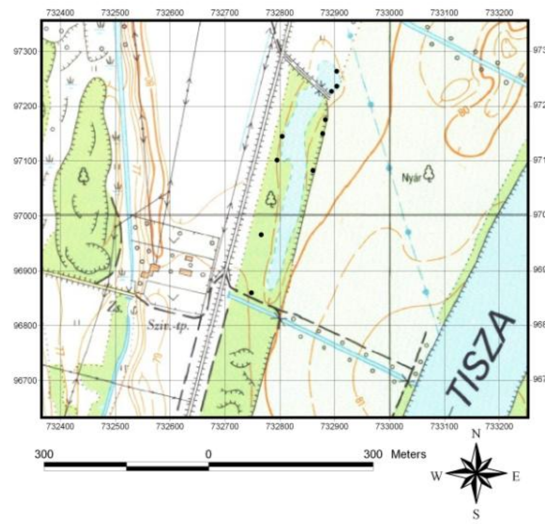
Distribution of sampling plots at the seven study sites



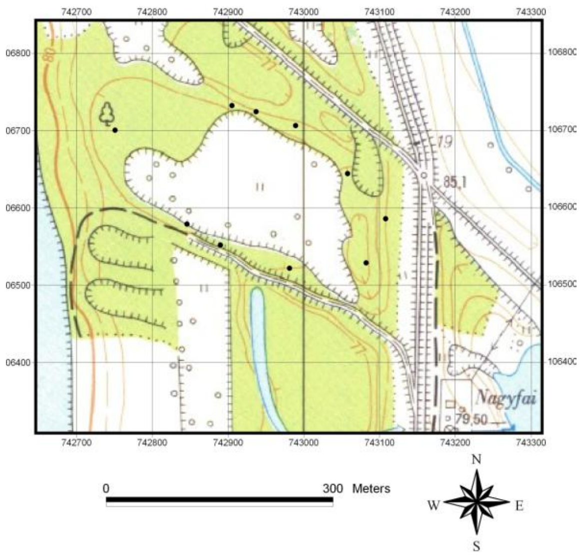
Atka



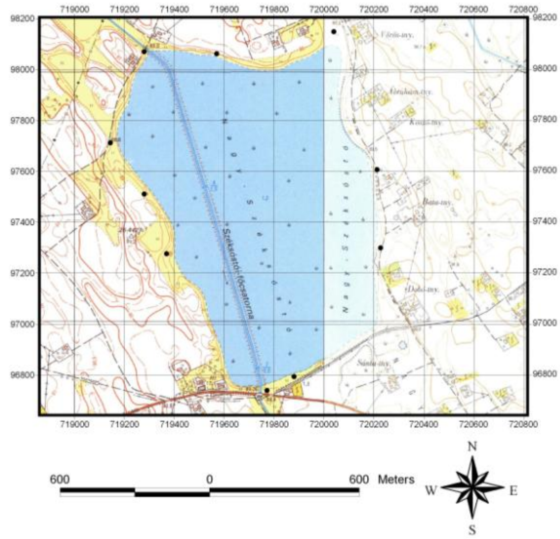
Hattyas



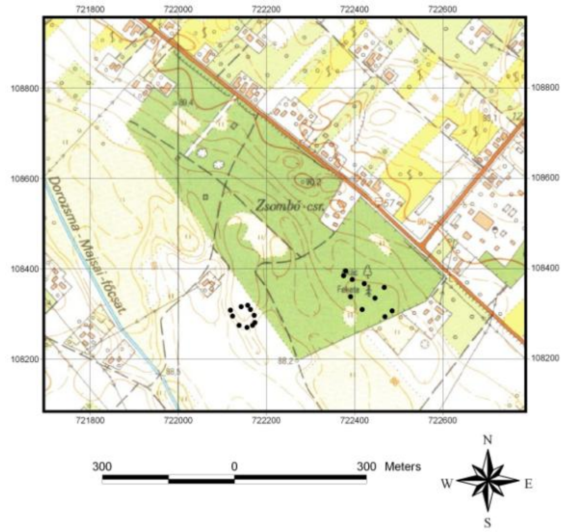
Gyálarét



Nagyfa



Nagyszéksós tó



Zsombó fen and artificial pond

TISCIA 38, 19-27

A NEW POPULATION OF *ASTRAGALUS DASYANTHUS* PALL. IN THE SOUTHERN KISKUNSÁG (HUNGARY)

Z. Bátori, A. Kelemen, E. Aradi and M. Zalatnai

Bátori, Z., Kelemen, A., Aradi, E. and Zalatnai, M. (2011): A new population of *Astragalus dasyanthus* Pall. in the Southern Kiskunság (Hungary) – *Tiscia 38, 19-27*

A new population of *Astragalus dasyanthus* was found near the village of Dóc ("Pitricsomi-legelő"), in Southern Kiskunság. The habitat of the new population was compared to the habitat of another population near the village of Bugyi ("Kettős-hegy"), Northern Kiskunság. Both populations occur in the association *Astragalo austriaci-Festucetum sulcatae* Soó 1957. However, 20 diagnostic species can be distinguished between the habitats of the two populations. The rates of natural pioneers and generalists are higher in the habitat of Bugyi, while the rate of disturbance tolerants is higher in the habitat of the newly discovered population. Habitats of *Astragalus dasyanthus* are warm and dry, basiphilous, and very poor in nitrogen.

Key words: Astragalus dasyanthus, diagnostic species, ecological indicator values, habitat conditions, PCoA, phytocoenological relevés, social behaviour types

Z. Bátori, M. Zalatnai, Department of Ecology, University of Szeged, H-6726 Szeged, Közép fasor 52, Hungary, **A. Kelemen**, Department of Ecology, University of Debrecen, H-4010 Debrecen, Egyetem tér 1, Hungary, **E. Aradi**, Directorate of the Kiskunság National Park, H-6000 Kecskemét, Liszt Ferenc utca 19, Hungary

INTRODUCTION

Astragalus dasyanthus Pall. (syn: *Astragalus eriocephalus* E. et K. 1800 non Willd., *Astragalus pannonicus* Schult. 1814, *Astragalus stolzenburgensis* Lerchenf. in Schur 1866, *Tragacantha dasyantha* (Pall.) Kuntze, *Tragacantha eriocephala* (Waldst. et Kit.) Kuntze) is a rare, lowland-collin, Pontic-Pannonian flora element (Soó 1966) that occurs in Bulgaria (Assyov and Petrova 2006), Hungary (Király 2009), Romania (Oprea 2005), Serbia (Josifović 1976), the States of the former Soviet Union (Moldova, Russia, Ukraine) (Yakovlev *et al.* 1996) and is extinct in Slovakia (Bertová 1988). It is a strictly-protected plant species of the Hungarian flora and placed on the IUCN Red List.

The occurrence of *Astragalus dasyanthus* in Hungary was mentioned in many works. Kitaibel found it in Bácska, Bánát, Nyírség, Tokaj-Eperjes Mountain and Mezőföld in the 18th-19th centuries (Gombocz 1945). Later, Rapaics (1916a) summarized the occurrences of *Astragalus dasyanthus* in the Carpathian Basin, and according to his opinion it was not common in Hungary. In the 20th century, many localities were found in Bácska and Bánát (Dégen 1904, Tuzson 1914, Lányi 1915 and Lengyel 1915), Hajdúság (Rapaics 1916b), Nyírség (Tamássy 1928), Zemplén Mountains (Kiss 1939, Soó 1940), Mezőföld (Zólyomi 1958, Lendvai and Horváth 1994, Horváth 1998, Szerényi 2000) and Transylvania (Prodán 1913, Soó 1940). Other populations were also found in the Kiskunság (Boros 1919, 1954). Moreover, in the 19th-20th centuries, many herbarium specimens were collected from the area of the Carphatian Basin (cf. Szujkó-Lacza 1981a). Up to now, some of the above-mentioned populations went extinct in Hungary (e.g. Nyírség) and many populations have become vulnerable or endangered and need special protection (Horváth 1997).

The aim of this study was to characterize the habitat of the new population of *Astragalus dasyanthus* near the village of Dóc ("Pitricsomi-legelő"). Moreover, the habitat of the new population was compared to the habitat of a similarly large population near the village of Bugyi ("Kettős-hegy", Northern Kiskunság).

Identification of Astragalus dasyanthus individuals

Astragalus dasyanthus is taxonomically problematic (cf. Szujkó-Lacza 1981b). Presumably, some *Astragalus dasyanthus* populations of the Danube-Tisza Interfluve are hybrids of *Astragalus dasyanthus* and *Astragalus exscapus* (Farkas 1999).

Only a small proportion of the individuals of the two investigated populations could be identified as typical *Astragalus dasyanthus* or *Astragalus exscapus* by species identification keys according to Soó and Jávorka (1951), Jávorka (1962), Heywood (1964), Soó (1966), Farkas (1999), Simon (2000) and Király (2009) as follows:

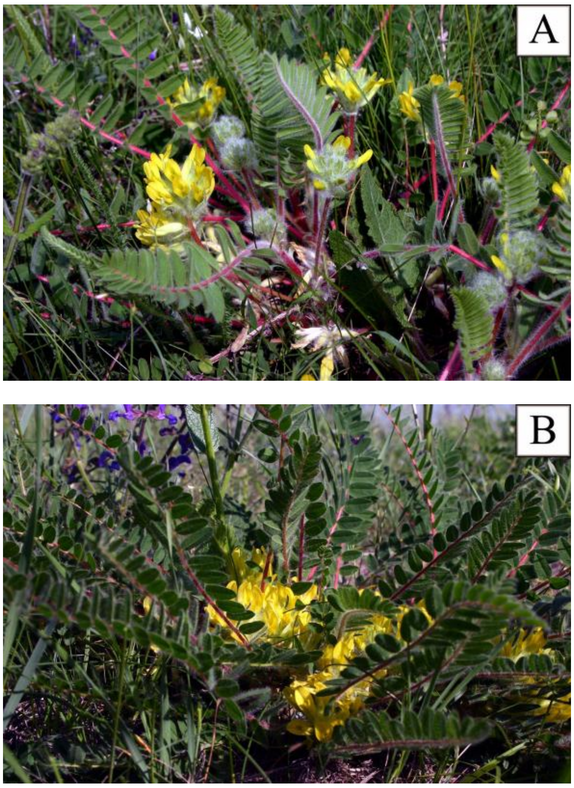


Fig. 1: *Astragalus dasyanthus* (A) and *Astragalus exscapus* (B) individuals in the association *Astragalo austriaci-Festucetum sulcatae* near Dóc (original photos of Z. Bátori).

Astragalus exscapus: Acaulescent or almost so, leaves are bunched into a ground leaf rosette, peduncles are absent (f. *excapus*) or shorter than 7 cm (f. *caulifer*). Leaflets 6-30 pairs, narrowly oblong to orbicular-ovate. The whole plant is densley covered with white hairs. Corolla yellow; standard glabrous. Plant height is 5-10(-20) cm (Fig. 1B).

Astragalus dasyanthus: Caulescent with leafy stems, peduncles are longer than 5 cm. Leaflets 8-20 pairs, ovate-oblong to elliptic-lanceolate. The whole plant is densley covered with white hairs. Corolla yellow; standard hairy. Plant height is 10-25(-45) cm (Fig. 1A).

In contrast, most of the individuals found (67% in the population of Dóc, 89% in the population of Bugyi, respectively) were varying inside the ranges specified by the standard identification keys. Since this study does not aim to determine the rate of hybridisation of the individuals but to characterize the habitat of the new population, therefore all of the hybrid-like individuals were considered *Astragalus dasyanthus*.

MATERIAL AND METHODS

In the new habitat of the *Astragalus dasyanthus*, 10 phytocoenological relevés (2 m × 2 m) were taken according to the Braun-Blanquet methodology (Mueller-Dombois and Ellenberg 1974). For comparison, 10 relevés were also taken with the same method from the sandy vegetation of Bugyi. We arranged the species in Table 1 and Tabel 2 into syntaxonomical groups according to Horváth *et al.* (1995) and Soó (1980).

Presence-absence data were analysed using Principal Coordinate Analysis (PCoA) ordination (Jaccard index) with the program package SYN-TAX 2000 (Podani 2001).

Differential species were determined by fidelity measurement with the phi coefficient (Φ) of species belonging to the different locations (Chytrý *et al.* 2002). The Φ coefficient was computed with the JUICE 7.0.25 program (Tichý 2002). Species having a high fidelity (Φ > 0,55) were considered diagnostic.

Habitat conditions were analysed by the ecological indicator values (TWRN) built on the Ellenberg system and adapted to the Hungarian flora by Borhidi (1993). Characterization of the vegetation was carried out by using the social behaviour types (SBT) of Borhidi (1993, 1995). Distributions of TWRN and SBT values were calculated using both presence-absence and cover data.

Plant community names were used according to Borhidi (2003), and plant species names according to Király (2009).

RESULTS

Phytosociological characterization

The PCoA scattergram shows a clear separation of the relevés of the two *Astragalus dasyanthus* populations (Fig. 2). According to the cloud of points represented on the first 2 axes, habitat of the population near the village of Dóc is more homogenous.

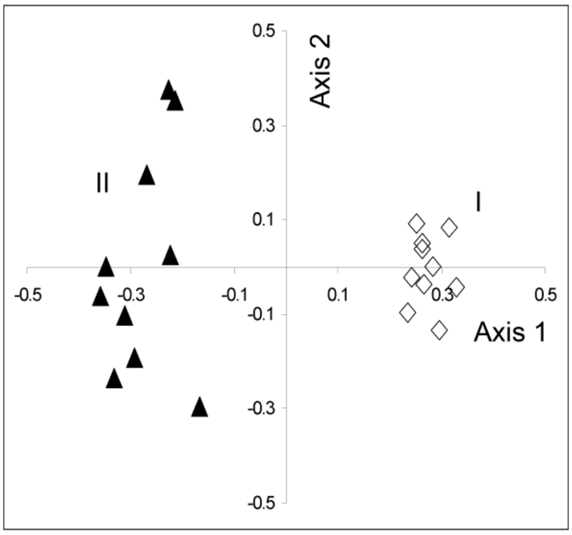


Fig. 2: PCoA ordination diagram of 20 relevés of the two investigated *Astragalus dasyanthus* populations. Notations: I: relevés of the population of Dóc; II: relevés of the population of Bugyi. Eigenvalues of the 1st and 2nd axes were 23.63% and 8.33%, respectively.

There are 20 diagnostic species between the two habitats of *Astragalus dasyanthus*. *Sonchus asper* (Polygono-Chenopodietalia), *Bothriochloa ischaemum*, *Carex tomentosa*, *Chrysopogon gryllus*, *Muscari neglectum*, *Myosotis stricta*, *Saxifraga tridactylites* (Festuco-Brometea), *Veronica prostrata* (Festucetalia valesiacae), *Ornithogalum umbellatum* agg. and *Vicia angustifolia* (indifferent) are diagnostic in the habitat of Dóc, while *Arenaria serpyllifolia*, *Galium verum*, *Koeleria cristata*, *Veronica verna* (Festuco-Brometea), *Cerastium pumilum*, *Cruciata pedemontana*, *Thymus pannonicus* (Festucetalia valesiacae), *Carex liparicarpos*, *Erysimum diffusum* (Festucetalia vaginatae) and *Bromus arvensis* (indifferent) in the habitat of Bugyi.

The new population of *Astragalus dasyanthus* (about 500-600 individuals) near the village of Dóc (CEU: 9586.4) occurs on a small sand hill, in the association *Astragalo austriaci-Festucetum sulcatae* Soó 1957, surrounded by alkaline grasslands such as *Agrostio-Caricetum distantis* Rapaics ex Soó 1938, *Lepidio crassifolii-Puccinellietum limosae* Soó (1947) 1957 and *Bolboschoenetum maritimi* Eggler 1933. So it is not surprising that a Festuco-Puccinellietalia (*Podospermum canum*) and a Festucion-pseudovinae (*Ranunculus pedatus*) species also occur in the relevés. The vegetation of the sandy grassland is dominated by Festuco-Brometea and Festucetalia valesiacae species and some common species of dry habitats. The most important grass and sedge species include *Bothriochloa ischaemum*, *Carex tomentosa*, *Chrysopogon gryllus*, *Cynodon dactylon*, *Elymus repens*, *Festuca rupicola* and *Poa angustifolia*. In springtime, some annual and geophyte species (*Cerastium semidecandrum*, *Myosotis stricta*, *Muscari neglectum*, *Ornithogalum umbellatum* and *Saxifraga tridactylites*) are also common. The most typical dicotyledons are *Euphorbia cyparissias*, *Salvia pratensis*, *Verbascum phoeniceum* and *Vicia angustifolia*. Several rare and protected species were also detected in the deeper (*Ophioglossum vulgatum*, *Orchis coriophora*) and higher (*Astragalus exscapus*, *Centaurea sadleriana*, *Onosma arenaria*, *Orchis coriophora*) parts of the sand hill, contributing to the natural value of the area. The presence of *Ambrosia artemisiifolia*, *Cannabis sativa* subsp. *spontanea*, *Conyza canadensis*, *Descurainia sophia*, *Senecio vulgaris*, *Silene alba*, *Sonchus asper* and *Taraxacum officinale* indicates a mild disturbance. On the basis of the maps of the first, the second and the third military surveys, the habitat of *Astragalus dasyanthus* near Dóc must have been out of cultivation during the last 200 years. The patches of salt marshes, marshmeadows and sandy habitats had similar pattern, size and spatial location as they have recently. However, the adjacent patches are cultivated forest plantations, farms, villages and arable lands.

Astragalus dasyanthus population of Bugyi occurs in the association *Astragalo austriaci-Festucetum sulcatae* Soó 1957 of sand hills and interdune depressions. Its vegetation is dominated by Festuco-Brometea, Festucetalia valesiacae and indifferent species. However, there are some Festucetalia vaginatae and Festucion vaginatae species (*Alkanna tinctoria*, *Euphorbia segueriana*, *Carex liparicarpos*, *Erysimum diffusum*, *Sedum hillebrandtii* and *Silene conica*) occurring mainly on the southern slopes that cannot be found in the population of Dóc. The most important grass and sedge species include *Bromus arvensis*, *Carex liparicarpos*, *Festuca rupicola*, *Koeleria cristata* and *Poa angustifolia*. The most typical dicotyledons are *Arenaria serpyllifolia*, *Cerastium pumilum* subsp. *glutinosum*, *Cruciata pedemontana*, *Eryngium campestre*, *Erysimum diffusum*, *Galium verum* and *Veronica verna*. The vascular flora of this area contains lots of protected species such as *Astragalus asper, Alkanna tinctoria, Centaurea sadleriana, Sedum hillebrandtii* and *Stipa pennata.* Some disturbance tolerant and ruderal species (*Carduus nutans, Cirsium arvense, Cynodon dactylon* and *Elymus repens*) also occur in this habitat.

Vegetation features based on the social behaviour types

In the case of presence-absence data, the rate of disturbance tolerant plants (DT) is the greatest in the habitat of Dóc, while the rate of generalists (G) in the habitat of Bugyi (Fig. 3). The presence of natural pioneers (NP) is more determining in the habitat of Bugyi than in the habitat of the newly discovered population. In addition, the proportion of generalists is also important in the habitat of Dóc, and the proportion of disturbance tolerants in the habitat of Bugyi. The importance of specialists (S), competitors (C), native weed species (W) and ruderal competitors (RC) is nearly equal (5-10%) in both habitats. Introduced alien species (I) and adventives (A) occur only in the habitat of the newly discovered population.

When considering the cover data, the rate of competitors is the highest in both habitats. Nevertheless, generalists and disturbance tolerants show similar distributions to those of the presence-absence data. Specialists have a proportion of about 15% in both habitats.

Habitat conditions based on ecological indicator values

Habitats of the two investigated *Astragalus dasyanthus* populations show only small differences according to temperature (T), moisture supply (W), soil reaction (R), and nitrogen supply (N).

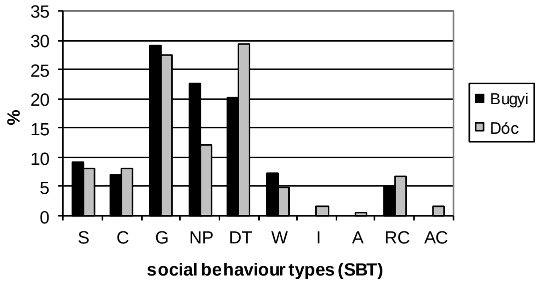
The use of T values with both presence-absence and cover data shows that the proportion of T7 (plants of thermophilous forest or woodland belt) species is the highest in the T indicator spectra, but the rates of T5 (plants of montane mesophilous broad-leaved forest belt), T6 (plants of submontane broad-leaved forest belt) and T8 (plants of sub-Mediterranean woodland and grassland belt) species are also considerable.

In the case of W indicator values, the maximum is found at W3 (xero-tolerants, but eventually occurring on fresh soils), but the proportion of W2 (xero-indicators on habitats with long dry period) species also reaches 10%. According to the presence-absence data, the rate of W1 (plants of extremely dry habitats or bare rocks) species is somewhat higher, while the rates of W5 (plants of semihumid habitats, under intermediate conditions) and W6 (plants of fresh soils) species are somewhat lower in the habitat of Dóc.

The rate of R8 (basiphilous plants) is the highest in both habitats, but R6 (mostly on neutral soils but also in acid and basic ones, generally widely tolerant, more or less indifferent plants) and R7 (basifrequent plants, mostly on basic soils) species also play an important role in the spectra.

The maximum of N spectra is found at N2 (plants of habitats very poor in nitrogen) in both habitats. The rate of N1 (only in soils extremely poor in mineral nitrogen) species is higher in the habitat of Bugyi, while the rate of N3 (plants of moderately oligotrophic habitats) is higher in the habitat of Dóc.

A



B

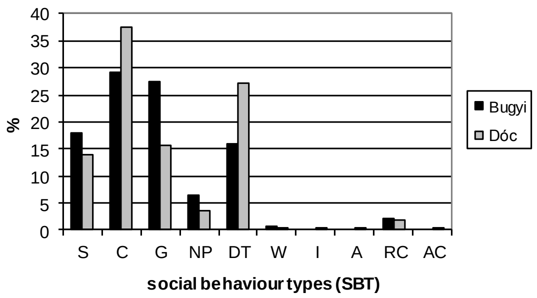


Fig. 3: Social behaviour types (SBT) based on presence-absence (A) and cover (B) data

DISCUSSION

Our paper deals with the characterization of a newly discovered population of *Astragalus dasyanthus* in the Southern Kiskunság, which is one of the most viable and most southern *Astragalus dasyanthus* population of Hungary.

According to our present knowledge, *Astragalus dasyanthus* is a rare and endangered plant species of Hungary, and occupies open or closed, and dry basiphilous habitats on loess or sand substrates, so it occures in loess or sandy grasslands (cf. Tuzson 1914, Boros 1919, Farkas 1999, Simon 2000, Király 2009). The new population of *Astragalus dasyanthus* near the village of Dóc occurs also in the association *Astragalo austriaci-Festucetum sulcatae*, and its habitat is dominated by Festuco-Brometea and Festucetalia valesiacae species, such as the habitat near the village of Bugyi, in Northern Kiskunság. Although both populations occur in the same association, there are some differences between the species composition and vegetation texture of the two habitats. In the habitat of Bugyi, the rate of plants living in open sand habitats (Festucetalia vaginatae and Festucion vaginatae species) is higher, while the rate of plants living in disturbed, secondary and artificial habitats (adventives, alien species, disturbance tolerants and ruderal competitors) is lower than in the habitat of Dóc. However, there are some alkaline species that occur only in this latter habitat. Both habitats of *Astragalus dasyanthus* are warm and dry, basiphilous, and very poor in nitrogen. The cause of these floristic differences may be defined as follows: different landscape pattern, different land use and treatment. For example, habitat of *Astragalus dasyanthus* near the village of Dóc was burnt off during the last two autumn seasons (in 2008 and 2009), but this treatment was omitted in 2010. The habitat of the new population was visited again in 2011. We surprisingly observed that most of the individuals were very small and rate of flowering was decreased due to the shade effect of leaf litter and tall grasses. This observation suggests that proper management of the area could increase the viability of *Astragalus dasyanthus* individuals.

Our results are in good agreement with many other studies which have pointed out that *Astragalus dasyanthus* populations of Hungary are very vulnerable and need special protection (cf. Farkas 1999). More investigations are necessary to clarify the taxonomic state of *Astragalus dasyanthus* and *Astragalus exscapus* populations of Hungary.

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REFERENCES

Assyov, B. and Petrova, A. (2006): Conspectus of the Bulgarian vascular flora. – Sofia, 453 pp.

Bertová, L. (ed.) (1988): Flora Slovenska IV/4. – VEDA, vydavatel'stvo Slovenskej akadémie vied Bratislava, Bratislava, 592 pp.

Borhidi, A. (2003): Magyarország növénytársulásai (Plant associations of Hungary). – Akadémiai Kiadó, Budapest, 610 pp.

Borhidi, A., 1993: A magyar flóra szociális magatartás típusai, természetességi és relatív ökológiai értékszámai (Social behaviour types of the Hungarian flora, its naturalness and relative ecological indicator values). – A Környezetvédelmi és Területfejlesztési Minisztérium Természetvédelmi Hivatala és a Janus Pannonius Tudományegyetem Kiadványa, pp. 93, Pécs.

Boros, Á. (1919): Újabb adatok Közép-Magyarország flórájának ismeretéhez (New data to the flora of Middle Hungary). – Botanikai Közlemények 19: 39-44.

Boros. Á. (1954): Florisztikai közlemények IV (Floristic notes IV). – Botanikai Közlemények 45(3-4): 247-250.

Chytrý, M., Tichý, L., Holt, J. and Z. Botta-Dukát (2002): Determination of diagnostic species with statistical fidelity measures. – Journal of Vegetation Science13: 79-90.

Degen, Á. (1904): *Bulbocodium ruthenicum* Bge. a Duna és a Tisza között (*Bulbocodium ruthenicum* Bge. between the Danube and Tisza rivers). – Magyar Botanikai Lapok 3: 218-219.

Farkas, S. (ed.) (1999): Magyarország védett növényei (Protected plants of Hungary). – Mezőgazda Kiadó, Budapest, 416 pp.

Gombocz, E. (ed.) (1945): Diaria itinerum Pauli Kitaibelii I-II. – Magyar Természettudományi Múzeum, Budapest, 1083 pp.

Horváth F., Dobolyi Z. K., Morschhauser T., Lőkös L., Karas L. and Szerdahelyi T. (eds) (1995): Flóra adatbázis 1.2 (Flora database 1.2) – Vácrátót, 267 pp.

Horváth, A. (1997): Az Adonyi Természetvédelmi Terület botanikai állapotának felmérése (Botanical survey of the protected area of Adony). – Kutatási jelentés a Budapesti Természetvédelmi Igazgatóság részére. Kézirat, 45 pp.

Horváth, A. (1998): A mezőföldi fátlan löszvegetáció florisztikai és cönológiai jellemzése (Loess flora and vegetation of the Mezőföld region). – Kitaibelia 3(1): 91-94.

Jávorka, S. (1962): Növényhatározó, II. kötet (Plant identification handbook II). – Tankönyvkiadó, Budapest, 527 pp.

Josifović, M. (ed.) (1976): Flore de Republique Socialiste de Serbie IV. – Academie Serbe des Sciences et des Arts, Beograd, 584 pp.

Király, G. (ed.) (2009): Új magyar füvészkönyv (New Hungarian Herbal). – Aggteleki Nemzeti Park Igazgatóság, Jósvafő, 616 pp.

Kiss, Á. (1939): Adatok a Hegyalja flórájához (Data to the flora of Hegyalja). – Botanikai Közlemények 36: 181-278.

Lányi, B. (1915): Csongrád megye flórájának előmunkálatai (Preliminary floristic analysis of Csongrád County). – Magyar Botanikai Lapok 13: 232-274.

Lendvai G., Horváth A. (1994): Adatok a Mezőföld löszflórájához (Data to the loess flora of Mezőföld region). – Botanikai Közlemények 81: 9-12.

Lengyel, G. (1915): A királyhalmi Magyar királyi külső erdészeti kísérleti állomás területe növényzetének ismertetése. (Vegetation of the royal forestry experimental station of Hungary) – Erdészeti Kísérletek 17: 50-73.

Mueller-Dombois, D., Ellenberg, H. (1974): Aims and methods of vegetation ecology. – John Wiley, London, 547 pp.

Oprea, A. (2005): Lista critică a plantelor vasculare din România. – Editura Universităţii „Alexandru Ioan Cuza", Iaşi, 668 pp.

Podani J. (2001): SYN-TAX 2000. Computer programs for data analysis in ecology and systematics. – Scientia Publishing, Budapest, 51 pp.

Prodán, Gy. (1913): A sármási földgázterület és környékének nyári flórája (Summer flora of the natural gas area of Sármás). – Botanikai Közlemények 12: 253.

Rapaics, R. (1916a): A gyapjas csűdvirágról (*Astragalus dasyanthus*). – A Kert 22: 459-461.

Rapaics, R. (1916b): Debrecen flórája (The flora of Debrecen). – Erdészeti Kísérletek 18(1-2): 28-80.

Simon, T. (2000): A magyarországi edényes flóra határozója

(Vascular flora of Hungary). – Nemzeti Tankönyvkiadó, Budapest, 846 pp.
Soó, R. (1940): A Sátorhegység flórájáról (Flora of the Sátor Hills). – Botanikai Közlemények 37: 169-187.
Soó, R. (1940): Az Erdélyi Mezőség flórája (Flora of the Transylvanian Mezőség). – Alföldi Nyomda, Debrecen, 125 pp.
Soó, R. and Jávorka, S. (1951): A magyar növényvilág kézikönyve I (Handbook of the Hungarian flora and vegetation I) – Akadémiai Kiadó, Budapest, 582 pp.
Soó, R. (1966): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve II (Systematic and geobotanical handbook of the Hungarian flora and vegetation II). – Akadémiai Kiadó, Budapest, 655 pp.
Soó, R. (1980): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve VI (Systematic and geobotanical handbook of the Hungarian flora and vegetation VI). – Akadémiai Kiadó, Budapest, 557 pp.
Szerényi, J. (2000): Adatok az Észak-Mezőföld löszflórájához (Data to the loess flora of North Mezőföld region). – Kitaibelia 5(2): 249-270.
Szujkó-Lacza, J. (1981a): Distribution and diversity of three *Astragalus* taxa (*Leguminosae*). – Studia Botanica Hungarica 15: 57-64.
Szujkó-Lacza, J. (1981b): Revision of three Astragalus taxa (*Leguminosae*) and their cenological relations. – Annales Historico-Naturales Musei Nationalis Hungarici 73: 83-100.
Tamássy, G. (1928): Florisztikai Közlemények (Floristic notes). – Botanikai Közlemények 25: 99-100.
Tichý, L., (2002): JUICE, software for vegetation classification. – Journal of Vegetation Science 13: 451-453.
Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., Webb, B. A. (eds) (1968): Flora Europaea II. – Cambridge University Press, Cambridge, 455 pp.
Tuzson, J. (1914): A Magyar Alföld növényformációi (Plant formations of the Great Hungarian Plain). – Botanikai Közlemények 13: 51-58.
Yakovlev, G. P., Sytin, A. K. and Roskov, Yu. (1996): Legumes of Northern Eurasia. – Royal Botanic Gardens, Kew, 724 pp.
Zólyomi B. (1958): Budapest és környékének természetes növénytakarója (Natural vegetation of Budapest and its surroundings). – In: Budapest természeti képe (Pécsi M. ed.), 509-642. Akadémiai Kiadó, Budapest.

Table 1: Analytical table of the habitat of *Astragalus dasyanthus* near the village of Dóc

	1	2	3	4	5	6	7	8	9	10	%	K
	Chenopodietea											
Senecio vulgaris	-	-	-	-	-	+	-	+	-	-	20	I
	Polygono-Chenopodietalia											
Sonchus asper	-	-	-	+	+	+	+	-	-	+	50	III
	Secalietea											
Cannabis sativa subsp. *spontanea*	-	-	-	-	+	-	-	-	-	-	10	I
Descurainia sophia	-	-	-	-	-	-	-	-	+	-	10	I
	Festuco-Brometea											
Arenaria serpyllifolia	-	-	-	-	-	-	-	-	+	-	10	I
Bothriochloa ischaemum	-	1	+	+	+	1	1	1	1	1	90	V
Carex praecox	-	-	-	-	-	2	-	-	1	2	30	II
Carex tomentosa	1	2	1	1	1	1	1	1	1	1	100	V
Chrysopogon gryllus	1	1	1	1	1	1	2	2	2	2	100	V
Eryngium campestre	-	-	-	-	+	-	+	-	-	+	30	II
Euphorbia cyparissias	+	+	-	-	-	+	+	+	+	+	70	IV
Falcaria vulgaris	-	-	-	-	-	-	-	+	-	-	10	I
Galium verum	-	-	+	1	-	-	-	+	-	-	30	II
Hypericum perforatum	-	-	-	+	+	+	+	+	+	-	60	III
Knautia arvensis	+	-	+	+	-	-	-	-	-	+	40	II
Koeleria cristata	+	-	-	-	1	1	2	-	1	-	50	III
Medicago falcata	-	-	+	-	-	-	-	-	-	+	20	I
Muscari neglectum	+	+	-	+	+	+	+	1	2	+	90	V
Myosotis stricta	+	+	+	1	+	+	1	1	+	+	100	V
Poa angustifolia	2	2	2	2	2	+	2	3	2	3	100	V
Potentilla arenaria	-	-	-	+	-	-	-	-	-	-	10	I
Saxifraga tridactylites	-	-	+	+	+	-	+	+	+	-	60	III
Trifolium montanum	-	+	+	-	+	-	-	-	-	-	30	II
Veronica verna	-	-	-	+	-	-	+	+	+	+	50	III
	Festucetalia valesiacae											
Centaurea sadleriana	-	-	-	-	-	-	-	-	+	-	10	I
Festuca rupicola	3	2	3	3	3	3	3	2	2	2	100	V
Salvia pratensis	1	1	1	-	2	1	-	-	1	2	70	IV
Verbascum phoeniceum	+	1	1	+	1	+	+	-	-	+	80	IV
Veronica prostrata	+	+	-	-	-	+	+	-	+	-	50	III
	Festucion valesiacae (incl. Festucion rupicolae)											
Astragalus dasyanthus	2	2	1	2	2	2	2	2	2	2	100	V
Astragalus exscapus	1	2	-	1	1	-	1	-	-	1	60	III
	Festucion vaginatae											
Cerastium semidecandrum	+	-	+	1	-	+	2	1	1	1	80	IV
Onosma arenaria	-	-	-	-	-	-	-	-	+	-	10	I
	Molinio-Arrhenatheretea											
Ophioglossum vulgatum	-	-	1	-	-	-	-	-	-	-	10	I
Orchis coriophora	+	-	+	+	-	-	-	-	-	-	30	II
Rhinanthus serotinus	-	1	+	-	-	-	-	+	+	-	40	II
	Festuco-Puccinellietalia											
Podospermum canum	1	-	-	+	-	-	-	-	-	-	20	I
	Artemisio-Festucetalia											
Achillea setacea	-	1	1	+	-	-	-	-	-	+	40	II
Carex stenophylla	-	-	-	-	-	-	-	1	-	-	10	I
	Festucion pseudovinae											
Ranunculus pedatus	-	-	-	+	+	+	+	-	-	-	40	II
	Indifferent											
Carex flacca	-	-	-	-	+	-	-	-	-	-	10	I
Crepis rhoeadifolia	-	-	+	-	+	-	-	-	-	-	20	II
Cynodon dactylon	+	+	1	+	1	+	+	+	+	-	90	V
Elymus repens	1	1	1	+	-	+	-	1	-	+	70	IV
Ononis spinosa	-	-	+	-	+	+	-	-	-	-	30	II
Ornithogalum umbellatum agg.	1	1	1	1	+	1	+	+	+	+	100	V
Silene alba	-	-	-	-	-	-	-	-	+	-	10	I
Taraxacum officinale	+	-	-	-	-	-	-	-	-	-	10	I
Trifolium campestre	+	-	-	+	-	+	+	+	1	-	60	III
Vicia angustifolia	1	1	+	1	1	1	1	2	1	2	100	V
Vicia hirsuta	+	-	-	-	-	-	-	-	-	-	10	I

	Adventives											
Ambrosia artemisiifolia	-	-	-	+	-	-	-	-	-	-	10	I
Celtis occidentalis	-	+	-	-	+	-	+	-	-	+	40	II
Conyza canadensis	-	-	-	-	-	+	+	-	+	-	30	II
Cover (%)	80	85	80	90	70	80	90	85	85	100		
Height (cm)	40	40	30	50	40	30	40	40	40	55		

Relevés 1-10 made by Z. Bátori (ined.). 2010.05.14

Table 2: Analytical table of the habitat of *Astragalus dasyanthus* near the village of Bugyi

	1	2	3	4	5	6	7	8	9	10	%	K
	Chenopodietea											
Echium vulgare	-	-	-	-	-	-	-	+	-	-	10	I
	Secalietea											
Papaver rhoeas	-	+	+	+	-	-	-	-	-	-	30	II
Rannunculus arvensis	-	-	-	-	-	+	+	-	-	-	20	I
	Convolvulo-Agropyrion											
Convolvulus arvensis	-	-	-	1	-	-	-	+	-	-	20	I
	Sedo-Scleranthetalia											
Poa bulbosa	-	-	-	-	-	-	-	1	-	-	10	I
	Festuco-Brometea											
Arenaria serpyllifolia	+	+	1	1	1	1	1	+	+	1	100	V
Carex praecox	-	-	-	-	1	-	-	-	-	-	10	I
Chrysopogon gryllus	-	-	-	-	-	-	2	2	2	-	30	II
Eryngium campestre	1	1	1	+	-	-	-	+	1	1	70	IV
Euphorbia cyparissias	1	1	-	-	+	1	-	1	-	-	50	III
Falcaria vulgaris	-	-	1	-	+	-	1	-	-	-	30	II
Filipendula vulgaris	-	-	-	-	-	2	2	-	2	-	30	II
Galium verum	1	1	1	1	2	1	1	-	1	1	90	V
Hypericum perforatum	-	-	-	+	-	-	+	1	-	-	30	II
Koeleria cristata	1	2	1	2	2	3	2	2	1	1	100	V
Medicago falcata	1	1	-	2	1	-	-	-	-	-	40	II
Medicago minima	+	-	-	-	+	-	-	1	-	-	30	II
Myosotis stricta	-	-	+	+	1	+	+	-	-	-	50	III
Nonea pulla	-	-	+	+	-	-	-	-	-	+	30	II
Phleum phleoides	-	-	-	-	-	2	2	-	-	1	30	II
Poa angustifolia	1	2	2	2	2	1	2	-	2	1	90	V
Potentilla arenaria	+	-	-	1	-	+	-	1	-	+	50	III
Salvia nemorosa	-	-	-	-	-	-	+	-	-	-	10	I
Silene otites	-	-	-	-	-	-	+	+	+	-	30	II
Veronica verna	+	+	+	+	+	1	+	+	+	+	100	V
	Festucetalia valesiacae											
Agropyron cristatum	3	1	3	-	-	-	-	-	-	-	30	II
Centaurea sadleriana	-	-	-	-	-	1	-	-	-	-	10	I
Cerastium pumilum subsp. glutinosum	1	+	1	1	-	+	1	-	1	1	80	IV
Cruciata pedemontana	+	-	+	+	+	+	+	-	+	1	80	IV
Cynoglossum officinale	-	-	-	-	-	-	-	+	-	-	10	I
Festuca rupicola	2	3	2	3	2	2	2	3	2	3	100	V
Gagea pusilla	-	-	-	+	-	-	-	-	-	-	10	I
Lithospermum arvense	-	+	+	+	-	-	-	-	-	+	40	II
Salvia pratensis	-	-	-	-	-	2	1	-	2	-	30	II
Stipa capillata	+	+	-	-	-	-	-	-	-	-	20	II
Stipa pennata	-	-	-	1	-	-	-	+	-	-	20	I
Thymus pannonicus	2	1	-	-	1	-	-	2	+	2	60	III
Verbascum phoeniceum	+	-	+	+	-	1	+	-	1	-	60	III
	Festucion valesiacae (incl. Festucion rupicolae)											
Anthemis ruthenica	-	+	-	+	-	-	-	+	+	-	40	II
Astragalus asper	-	1	-	-	2	1	-	-	-	-	30	II
Astragalus dasyanthus	2	2	4	2	2	2	2	+	2	3	100	V
Astragalus excapus	1	1	-	-	+	+	1	1	-	-	60	III
Salvia austriaca	-	-	-	-	-	-	+	+	-	-	20	I
Viola kitaibeliana	-	+	+	+	+	-	-	-	-	-	40	II

	Festucetalia vaginatae											
Carex liparicarpos	+	+	+	2	-	+	+	1	1	+	90	V
Erysimum diffusum	+	+	1	2	1	-	+	+	-	+	80	IV
	Festucion vaginatae											
Alkanna tinctoria	-	-	-	-	-	-	-	+	-	-	10	I
Cerastium semidecandrum	-	-	-	1	1	-	-	+	-	-	30	II
Euphorbia sequreiana	-	-	-	-	-	-	-	1	-	-	10	I
Sedum hillebrandtii	-	-	-	-	-	-	-	1	-	-	10	I
Silene conica	+	-	-	-	-	-	-	+	-	+	30	II
	Molinio-Arrhenatheretea											
Achillea millefolium	-	-	-	-	-	1	-	1	1	1	40	II
Linum catharticum	-	+	+	1	-	-	-	+	-	-	40	II
	Artemisio-Festucetalia											
Achillea setacea	-	-	+	2	+	1	1	-	-	+	60	III
Carex stenophylla	-	-	+	-	-	1	-	-	-	-	20	I
	Indifferent											
Anchusa officinalis	-	-	-	-	+	-	-	-	-	-	10	I
Bromus arvensis	-	+	-	+	+	-	-	+	+	+	60	III
Carduus nutans	-	-	-	-	-	-	-	+	-	-	10	I
Carex hirta	-	-	-	-	-	+	-	-	-	-	10	I
Cirsium arvense	-	+	-	-	-	-	-	-	-	-	10	I
Cynodon dactylon	+	2	-	1	-	-	-	+	-	+	50	III
Elymus repens	-	-	-	-	1	1	1	-	1	-	40	II
Erodium cicutarium	-	-	-	+	-	-	-	+	-	-	20	I
Muscari comosum	-	-	-	+	-	-	-	-	-	-	10	I
Ornithogalum umbellatum agg.	-	-	-	-	-	-	-	+	-	-	10	I
Plantago lanceolata	-	-	-	-	-	-	-	+	-	-	10	I
Potentilla argentea	-	-	-	-	-	-	+	-	-	-	10	I
Silene alba	-	-	-	+	-	-	-	-	-	-	10	I
Taraxacum officinale	-	+	-	-	-	-	-	-	-	-	10	I
Trifolium campestre	-	-	-	-	-	-	-	-	-	+	10	I
Veronica arvensis	-	-	-	+	-	-	-	-	-	-	10	I
Cover (%)	95	90	100	95	95	95	95	80	95	95		
Height (cm)	45	40	40	50	45	45	50	40	45	45		

Relevés 1-10 made by A. Kelemen (ined.). Date: 2010.05.24