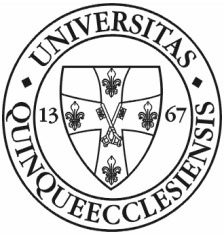
UNIVERSITY OF PÉCS
Biological Doctoral School
Botany Program

Host range, host and habitat specificity of the Hungarian *Cuscuta* species

PhD thesis

Kornél Baráth

Supervisor:
Dr. János Csiky
associate professor



PÉCS, 2012

KORNÉL BARÁTH
University of Pécs, Faculty of Sciences
Institute of Biology, Department of Plant Systematics and Geobotany
H-7624 Pécs, Ifjúság u. 6. Hungary
Phone: (+36) 72 503 600 / 4441
E-mail: barikori@yahoo.com

1. INTRODUCTION

Similar to human society, the kingdom of plants also contains some unusual members, which are strongly different from others in appearance and lifestyle. Such plants are the parasitic plants that partly or completely depend on the hosts for resources.

One of the most characteristic stem parasitic plants are the dodders (*Cuscuta*), which can be advanced obligate hemiparasite or holoparasite. Dodders are rootless parasites with twining, thin stems, small flowers and almost totally reduced, scale-like leaves. They coil around the stems or leaves of the hosts and penetrate to their vascular system with specialized absorptive organs, called haustoria, in order to absorb water, carbohydrates and minerals.

In spite of that several *Cuscuta* species are dangerous agricultural pests, their host range and host choice have not been sufficiently investigated. The majority of the references regarding the host spectra of dodders concern mainly cultivated plants, while most observations in natural or seminatural habitats are accidental supplements of other (taxonomical, physiological) studies on *Cuscuta*.

Although some excellent laboratory experiments focused on the active host choice of some dodders, our knowledge about the underlying mechanisms of the host selection under natural conditions is also quite insufficient.

The knowledge of the host preference of dodders can be important for agronomy, plant pathology, ecology and plant taxonomy. However, all of the available methods to investigate that have some kind of deficiency. Firstly, in most cases the conclusion was drawn only from the frequency and/or intensity of infestations. Although, based on this data we get a picture about the resource/host use by parasites, the knowledge of the resource/host availability is also essential to evaluate the host preference.

Secondly, the presently known methods are serviceable only at one location. In consequence of that, just a few host species can be compared by them. Moreover, several factors can result in differences in host quality that are not dependent on the identity of the host species. Since the influential effect of these factors can be neither evaluated nor eliminated under natural conditions, reliable conclusion concerning the preference of the host species cannot be drawn from studies that were conducted only at one location.

2. AIMS

These unique parasitic plants have been the object of several ecological studies and research. In spite of that or maybe for this reason the international literature is full of contradictions. On the other hand, some special fields of ecology of *Cuscuta* are largely unexplored.

The purpose of my study was to get thorough knowledge about the host range, host preference, host and habitat specificity of *Cuscuta* species in Hungary, and to clarify the contradictions that exist in the literature. I addressed the following questions:

2.1 How many host species can be parasitized by the different *Cuscuta* species in Hungary?

2.2 What kind of qualitative difference can be observed among the host ranges of native dodders?

2.3 What kind of regularities can be recognized in the process of the host choices of dodders?

2.4 How strong is their fidelity to various hosts? Is there any host specificity towards different host species?

2.5 How strong is the intensity of parasitism on various hosts? Is there any host preferences towards different host species?

2.6 How far do the habitats of Hungarian dodders differ from each other?

2.7 How strong is their fidelity to these habitats and what kind of factors can be responsible for this?

3. MATERIAL AND METHODS

The study was carried out on the recent *Cuscuta* species (*C. europaea*, *C. campestris*, *C. epithymum*, *C. lupuliformis*, *C. australis*, *C. approximata*) between 2003–2009 at 186 localities in Hungary. Both parasitised and unparasitised plants were examined in the habitats using altogether 407 representative quadrats. During the investigation of host ranges, host choices and habitats, I recorded the time and location of the relevés, the general description of habitats, the slope exposition and slope angle, the elevation above sea level, the parasitism status, cover and maximum height of the plant species that was found in the quadrat as well as the stem thickness of dodders. In addition during the study of host preferences, I recorded the phenological state of plants, estimated the percentage of the total *Cuscuta* cover on the particular host species, and distinguished six relationship types between hosts and parasite. I collected 57 soil samples in the habitats of dodders and determined their $CaCO_3$-, Ca-, NO_3-N + NO_2-N -, P_2O_5-, K_2O-, Mg-, Na-, Zn-, Cu-, Mn-, SO_4-S-, Fe- and total salt content. I also examined their acidity (pH-KCl), humus content (H %), and the soil granularity.

The qualitative differences among the host ranges of dodders and among the species compositions of habitats were investigated based on the taxonomic heterogeneity, on the Raunkiaer life-form system and on the geographical distribution types of the host species.

The host ranges and the species compositions were also compared on the basis of TB, WB, RB, NB indicator values as well as according to the social behaviour types of the host species.

The validity of the results was tested by statistical methods. Inter-group difference was investigated using the Brunner-Munzel test or the Mann-Whitney test. Homogeneity of variances was assessed by Levene's test. The homogeneity of the groups was tested by Pearson's chi-square test. The degree of correspondence between groups was measured by Kendall's τ rank correlation coefficient. Significance differences among the data of soil samples were determined by the Kruskal-Wallis test, followed by nonparametric multiple comparisons (Mann-Whitney tests with Bonferroni correction). Kruskal-Wallis, Mann-Whitney and Levene's tests were performed with ROPstat, while the Kendall's τ and χ-square test were performed with the PAST statistics software package.

The host ranges of dodders and the species compositions in their habitats were also investigated by multivariate data analysis. The two-dimensional PCoA ordination (Jaccard and Simple matching distance matrix) and the cluster analysis (beta-flexible method with Jaccard distance matrix) were performed using the software package Syntax.

The host spectra of the Hungarian *Cuscuta* species were compiled based on the field studies, on data of several herbaria and on the few literature sources concerning Hungary.

4. RESULTS

During the seven year study, I examined altogether 6150 plant-parasite relationships and recorded more than 35 000 field data records.

4.1 Since the terms and definitions regarding the parasite lifestyle were used with different meanings in the international literature, it was necessary to clarify and exactly define these terms and expressions. During the process, I have systematized the expressions for the topic of host specificity and I have created three new terms.

4.2 Compiling the host spectra of the various *Cuscuta* species based on herbaria, literature and my own observations, it can be said that dodders infest at least 572 plant species in Hungary, which is approximately 26% of the vascular flora of the country.

4.3 In my study, *C. epithymum* displayed the largest host range among the parasites. The results suggest that besides the frequency, the taxonomic complexity of the species is the reason for this.

4.4 I revealed the importance of the exclusive host species, and drew the attention to that each *Cuscuta* species can be identified by the host species in Hungary in the overwhelming majority of cases.

4.5 Based on the results, it can be concluded that the habitat differences of the *Cuscuta* species are responsible for the different host ranges.

4.6 It was also found that the reason why dodders parasitize plant species from various life-forms in different proportion is not the active host choice, but the species composition of the habitats.

4.7 I observed that the habitat of *C. epithymum* is more natural, than the habitats of other dodders, but it is quite heterogeneous.

4.8 I verified the host-generalist nature of the Hungarian dodders with several methods, and proved that the mature *Cuscuta* species can parasitize almost every plant that comes into contact with it in the natural habitats.

4.9 I listed the plants that were found to display some reaction against the infestation of dodders. I was the first to report that the species *Equisetum arvense, E. telmateia, E. ramosissimum* and *E. palustre* are able to prevent the parasitism by their hypersensitive reaction.

4.10 In my study the results from the methods of multivariate analysis confirmed the observation that the habitats of the Hungarian *Cuscuta* species are fundamentally different, but they can be adjacent, moreover in cases of some species they can overlap each other.

4.11 In the international literature regarding dodders, I was the first to reveal that the soils deriving from the habitats of several *Cuscuta* species are significantly different in many aspects. It is important because these differences (e.g. amount and proportion of the macro- and microelements in the soil) are independent from the identity of the host species.

4.12 I proved that there are not any host species of *C. europaea, C. campestris, C. epithymum, C. lupuliformis* and *C. australis*, which are essential and necessary for the survival of the parasites.

4.13 During my study, I have developed a new method for evaluating the host preference of dodders (and many other stem-parasitic plants). This technique takes account of the frequency and intensity of infestations, the proportion of the resource use and availability, the resource distribution as well as the defence mechanisms of the hosts. The process categorizes not only the host species but each infestation respectively, and establishes an order of preference among the host species.

This method considers also the fact that the preference status of a host species may considerably vary under different circumstances (under different species environments or/and in different habitats).

4.14 The results suggest that, plant species of N-poor habitats cannot be preferred host for *C. europaea*. I also proved that this dodder displays prominent preference towards *Urtica dioica* and *Humulus lupulus.*

4.15 In the case of *C. campestris* I observed significant preference towards therophytes. According to the results, the preference status can greatly vary among the host species belonging to the same genus.

4.16 Although nitrogen was found to be an important factor in host preference of dodders, I observed that *C. epithymum* occurs mostly in N-poor habitats. However this parasite shows strong preference towards the members of *Fabaceae*, which are able to utilize the atmospheric nitrogen with the help of *Rhizobium* bacteria.

4.17 I proved that *C. lupuliformis* adapted to parasitize woody plants, and display the strongest preference to *Salix triandra.*

4.18 In my study I verified that *C. australis* shows preference towards the members of *Polygonaceae* and also revealed that this dodder is the only Hungarian *Cuscuta* species that can preferentially parasitize grasses.

5. LIST OF PUBLICATIONS

5.1 Publications connected to the thesis

5.1.1 Books and book chapters

Baráth, K. (in press): *Cuscuta campestris*. In: Csiszár, Á. (szerk.): Inváziós növényfajok Magyarországon. – Nyugat-magyarországi Egyetem Kiadó.

Baráth, K. & Csiky, J. (2009): *Cuscutaceae*. – In: Király, G. (szerk.) Új magyar füvészkönyv – Magyarország hajtásos növényei. – Határozókulcsok. Aggteleki Nemzeti Park Igazgatóság, Jósvafő, pp. 333–335.

Baráth, K. (2007): A magyarországi *Cuscuta* fajok gazdaspecifitása, elterjedése, taxonómiája. – In: Salamon–Albert, É. (szerk.) Növénytani kutatások a Pécsi Tudományegyetemen. Pécsi Tudományegyetem, Pécs, pp. 52–56.

Baráth, K. & Csiky, J. (2006): *Cuscuta*. – In: Ujhelyi, P. & Molnár, V. A. (szerk.) Élővilág enciklopédia. – A Kárpát–medence gombái és növényei. Kossuth Kiadó, Budapest, pp. 428–430.

5.1.2 Peer-reviewed articles

Baráth, K. & Csiky, J. (2012): Host range and host choice of *Cuscuta* species in Hungary. – Acta Botanica Croatica 71(2): 215–227. IF: 0,702

Baráth, K. (2012): A new method for evaluating host preference of *Cuscuta* species. – Acta Botanica Hungarica 54(3–4): 219–234.

Baráth, K. (2010): The *Cuscuta* subgenus *Grammica* (*Convolvulaceae*) on the Palni hills with a new record. – Acta Botanica Hungarica 52(3–4): 227–238.

Baráth, K. (2009): The Genus *Cuscuta* L. (*Convolvulaceae*) in the Andaman Islands with a new record. – Acta Botanica Hungarica 51(3–4): 261–272.

Csiky, J. Baráth, K. Lájer, K. (2004): *Cuscuta* species in Hungary. – Journal of Plant Diseases and Protection 19: 201–208. IF: 0,833

5.1.3 Scientific presentations and posters

Baráth, K. (2012): Új módszer a *Cuscuta* fajok gazdapreferenciájának mérésére. – Magyar Biológiai Társaság, Botanikai szakosztály, 1450. szakülés, Budapest. – Botanikai Közlemények (in press).

Baráth, K. Csiky, J. Lengyel, A. (2012): A magyarországi arankafajok élőhelyspecifitása. – Magyar Biológiai Társaság, Botanikai szakosztály, 1450. szakülés, Budapest. – Botanikai Közlemények (in press)

Baráth, K. & Csiky, J. (2008): Host and Habitat Specificity of the *Cuscuta* species in Hungary. – 5th International Weed Science Congress. Vancouver, Canada. Abstract p. 75.

Baráth, K. (2008): Virág– és szármorfológiai vizsgálatok a *Cuscuta* nemzettségben. – Aktuális Flóra és Vegetácókutatás a Kárpát–Medencében VIII. Gödöllő. Kitaibelia XIII (1): 144.

Baráth, K. (2008): A magyarországi *Cuscuta* fajok ökológiája. – Magyar Biológiai Társaság, Pécsi Csoport, 217. szakülés. Pécs.

Baráth, K. (2007): A *Convolvulaceae* család taxonómiai vizsgálata Indiában. – Magyar Biológiai Társaság, Botanikai szakosztály, 1428. szakülés. Budapest. Botanikai Közlemények 94(1–2): 208.

Csiky, J. Baráth, K. Lajer, K. (2004): *Cuscuta* species in Hungary. – 22nd German Conference on Weed Biology and Weed Control. Stuttgart–Hohenheim, Germany.

Baráth, K. Csiky, J. Lájer, K. (2004): A magyarországi *Cuscuta* fajok elterjedése és gazdaspecifitása. – Aktuális Flóra és Vegetácókutatás a Kárpát–Medencében VI. Keszthely. Összefoglaló kötet: 18–19.

Csiky, J. Baráth, K. Lajer, K. (2004): A magyarországi *Cuscuta* fajok azonosítása, gazdaspecifitása, termőhelyi sajátságai. – 50. Növényvédelmi Tudományos Napok, Gyomnövények, Gyomszabályozási szekció. Magyar Tudományos Akadémia, Budapest. Összefoglaló kötet: 114.

Baráth, K. & Csiky, J. (2003): Baranya-megye *Cuscuta* fajai. – Lippai János – Ormos Imre – Vas Károly Tudományos Ülésszak, Botanikai szekció. BKÁE. Budapest. Összefoglaló kötet: 128.

Csiky, J. & Baráth, K. (2003): Taxonómiai és termőhelyi vizsgálatok a *Cuscuta campestris*, *C. europaea* és *C. epithymum* agg. populációkon. Magyar Biológiai Társaság, Botanikai szakosztály, 1394 szakülés. Budapest.

5.2 Publications not connected to the thesis

5.2.1 Books and book chapters

Baráth, K. Bátori, Z. Csiky, J. Erdős, L. Oláh, E. Pál, R. Purger, D. Schmidt, D. (2007): Borhidi Attila doktorandusz tanítványainak geobotanikai erdeményei. – In: Salamon–Albert, É. (szerk.) Növénytani kutatások a Pécsi Tudományegyetemen. Növényrendszertani és Geobotanikai Tanszék, Pécs, p. 90–97.

5.2.2 Peer-reviewed articles

Bátori, Z. Baráth, K. Csiky, J. (2006): A *Dryopteris affinis* (Löwe) Fras.–Jenk. előfordulása a Mecsekben. Flora pannonica 4: 3–8.

Csiky, J. Oláh, E. Baráth, K. (2005): A *Medicago nigra* (L.) Krock. Magyarországon. – Flora Pannonica 3: 49–55.

5.2.3 Scientific presentations and posters

Baráth, K. & Urbanics, M. (2012): Florisztikai vizsgálatok a Keleti–Alpokban. – Magyar Biológiai Társaság, Pécsi Csoport, 243. szakülés. Pécs.

Baráth, K. & Pereszlényi, Zs. (2010): A florisztikai kutatások újabb eredményei az Andaman–szigeteken. – Magyar Biológiai Társaság, Botanikai szakosztály, 1442. szakülés. Budapest. Botanikai Közlemények 97(1–2): 180.

Baráth, K. (2010): A florisztikai és vegetációs kutatások újabb eredményei Indiában. – Magyar Biológiai Társaság, Pécsi Csoport, 231. szakülés. Pécs.

Csiky, J. Bán, T. Baráth, K. Kovács, D. Lengyel, A. Wirth, T. (2010): Mapping the vascular flora of Pécs (Hungary): diversity, changes, naturalness. – Third Croatian Botanical Congress. Murter, Croatia. In: Jasprica, N. Pandža, M. Milović, M. (szerk): Book of Abstracts p. 64.

Erdős, L. Baráth, K. Körmöczi, L. Bátori, Z. Morschhauser, T. (2009): Karsztbokorerdők szegélyének diverzitásáról. – VIII. Magyar Ökológus Kongresszus. Szeged. Abstract p. 128.

Csiky, J. Baráth, K. Bátori, Z. Bodonczi, L. Mesterházy, A. Lengyel, A. Oláh, E. Pfeiffer, N. (2008): A *Dryopteris affinis* s.l. hazai elterjedéséről és élőhelyi preferenciájáról. – Aktuális Flóra és Vegetácókutatás a Kárpát–Medencében VIII. Gödöllő. Kitaibelia XIII (1): 155.

Bán, T. Csiky, J. Lengyel, A. Baráth, K. Oláh, E. (2008): Özönnövények grid alapú felmérése Pécs belterületén. – Aktuális Flóra és Vegetácókutatás a Kárpát–Medencében VIII. Gödöllő. Kitaibelia XIII (1): 143.

Baráth, K. Balcar, T. Stewart, B. (2008): A Palni hegy (India) növényvilága és veszélyeztetettsége. – Magyar Biológiai Társaság, Botanikai szakosztály, 1431. szakülés. Budapest.

Baráth, K. (2008): Brit–Kolumbia (Kanada) növényvilágának érdekességei. – Magyar Biológiai Társaság, Pécsi Csoport, 215. szakülés. Pécs.

Baráth, K. & Tóth, Z. (2008): Florisztikai vizsgálatok az Andaman szigetvilágon. – Magyar Biológiai Társaság, Pécsi Csoport, 211. szakülés. Pécs.

Tóth, Z. & Baráth, K. (2008): Az Andaman–szigetek (India) állatvilága. – Magyar Biológiai Társaság, Pécsi Csoport, 212. szakülés. Pécs.

Baráth, K. & Tóth, Z. (2007): Az Andaman–szigetek növényvilága és kutatottságának helyzete. Magyar Biológiai Társaság, Botanikai szakosztály, 1423. szakülés. Budapest.

Csiky, J. Botta–Dukát, Z. Oláh, E. Molnár, V. A. Pál, R. Pfeiffer, N. Baráth, K. (2006): Vegetation of vernal pools on the Hungarian segetal fields. – European Vegetation Survey, 15th workshop. Vegetation in agricultural landscapes and Natura 2000. Catania. p. 15.

Oláh, E. Csiky, J. Baráth, K. (2006): Belvizes szántók Nanocyperion fajai és vegetációtípusai a Drávamenti–síkság területén. – Aktuális Flóra és Vegetácókutatás a Kárpát–Medencében VII. Debrecen. Kitaibelia XI (1): 19.

Oláh, E. Csiky, J. Baráth, K. (2005): Iszaplakó fajok és növénytársulások a Drávamenti–sikon. MBT. Pécsi Csoport. 192. Pécs.

Oláh, E. Csiky, J. Baráth, K. (2005): A Drávamenti–sikság belvizes szántóinak Nanocyperion fajai és vegetáció típusai. – Magyar Biológiai Társaság, Botanikai szakosztály, 1414. szakülés. Budapest. Bot. Közlem. 92(1–2): 223.