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BIOPOP – A DATABASE OF PLANT TRAITS AND INTERNET APPLICATION FOR NATURE CONSERVATION

Peter Poschlod[1], Michael Kleyer[2], Anne-Kathrin Jackel[1], Andrea Dannemann[2] & O. Tackenberg

1) Institute of Botany, University of Regensburg, D-93040 Regensburg, Germany; e-mail peter.poschlod@biologie.uni-regensburg.de, anne-kathrin.jackel@biologie.uni-regensburg.de
2) Landscape Ecology Group (FB 7), Carl von Ossietzky University of Oldenburg, D-26111 Oldenburg, Germany; e-mail michael.kleyer@uni-oldenburg.de, andrea.dannemann@uni-oldenburg.de

Abstract: In scientific literature there is a wealth of information about the ecological and life-history traits of plant species. This information would be very valuable for a functional analysis of the response of species and communities to environmental changes and subsequent vulnerability/viability analysis or predictive modelling. However, the information is scattered in a multiple of different sources. Researchers often are discouraged from searching all available information.

We are compiling a database of plant traits of the flora of Germany. Our aim is to create a comprehensive, well documented database to be made freely accessible within FLORAWEB, an Internet portal of the German Federal Agency for Nature Conservation (BfN). An interactive user-interface will enable the data to be readily used for extracting biological risk factors and for decision-making in nature conservation.

A further aim of the project is to develop an application to enable simple predictions of plant population responses to habitat conservation or restoration management.

Keywords: Plant conservation, Plant functional types, Plant management, Plant vulnerability analysis

THE PROBLEM: INFORMATION ON PLANT TRAITS ARE DIFFICULT TO ACCESS

Plant traits are an important tool in basic and applied plant population biology and vegetation science (WEIHER et al. 1999). Many of them are fundamental for the functional analysis of the response of plant populations and communities to changes in the environment (POSCHLOD et al. 2000). By the recognition of plant functional types, i.e., groups of species with similar trait combinations and similar responses to environmental factors (GITAY & NOBLE 1997), plant traits are expected to become an important means for predicting the responses of populations and plant communities to environmental changes. They can be used:

(a) to recognize biological risk factors for individual plant species, for a better assessment of their endangered status in a locally and regionally changing environment (plant species/population vulnerability or viability analysis; e.g. SCHMID & MATTHIES 1994),

(b) for decision-making in species and habitat conservation and restoration programs (POSCHLOD et al. 1998), in planning (POSCHLOD 1999), in impact assessment (KLEYER 1999a), in connection with global change (DIAZ & MARCELO 1997),

(c) to optimize nature management practices (KAHMEN et al. 2002),

(d) for (predictive) modelling of population or even vegetation dynamics (BELDE 2001).

During recent years several papers have been published showing functional relationships between plant traits and changes in species frequency but also species composition in a changing cultural landscape and in connection with nature management and restoration (BAKKER et al. 1996, FISCHER & STÖCKLIN 1997, GRIME et al. 1997, LAVOREL et al. 1997, BONN & POSCHLOD 1998, DIAZ et al. 1998, ERIKSSON & JAKOBSSON 1998, POSCHLOD & BONN 1998, POSCHLOD et al. 1998, KLEYER 1999b, 2002, STÖCKLIN & FISCHER 1999, JAKOBSSON & ERIKSSON 2000, TACKENBERG 2001, KAHMEN et al. 2002).

Better knowledge of the biology and ecology of endangered species is expected to facilitate the detailed analysis of the factors causing their decline and to be prerequisite for a true turning-point in species conservation (GIGON et al. 1998, KORNECK et al. 1998).

In scientific literature, but also in unpublished manuscripts, there is a wealth of information about ecological and life-history traits of plant species. For a long time, detailed data have been collected for single species within "Biological Floras" such as those of Germany (KIRCHNER et al. 1908–1936), the British Isles (BRITISH ECOLOGICAL SOCIETY 1941, CLAPHAM et al. 1958), Moscow region (RABOTNOV 1974–1990) and Canada (CAVERS & MULLIGAN 1972). Important information about Central European species is also to be found in references from the Russian language sphere, e.g. in GATSUK (1980), SEREBRYAKOVA (1971) and in the references cited in the bibliography of RABOTNOV (1986a,b, 1987). However, all in all, these different floras cover only several hundred species in total (POSCHLOD et al. 1996) which was the reason why this approach was recently initiated also in Central Europe (MATTHIES & POSCHLOD 2000).

Several electronic database approaches were started to cover a more extensive number of species. Some of them include mostly general data which were taken over from floras (FRANK & KLOTZ 1990). Other databases started to compile scattered data from a multitude of different original sources such as FITTER & PEAT (1994) or KLEYER (1995) or even include own measurements such as GRIME et al. (1988); see also HODGSON et al. (1995). Also available are databases covering smaller trait sets (e.g. seed bank type, THOMPSON et al. 1997) or a specific trait group (e.g. clonality, KLIMEŠ & KLIMEŠOVÁ 1999). A new version of the database from FRANK & KLOTZ (1990), recently published (KLOTZ et al. 2002), covers about 60 traits.

However, researchers, especially in applied science and conservation, are still often discouraged from searching and compiling all available information.

BIOPOP – A DATABASE OF PLANT TRAITS AND INTERNET APPLICATION FOR NATURE CONSERVATION

We are compiling a database of plant traits from existing databases and from published and unpublished literature for the Central European flora. Our aim is to create a comprehensive, transparent, fully referenced database to be made freely accessible within FLORAWEB, an Internet portal of the German Federal Agency for Nature Conservation (BfN; www.floraweb.de).

Table. 1. Traits to be included in BIOPOP. Normal font – traits completely covered in available literature; bold – traits measured for the North-West European flora within LEDA (see text); italics – traits missing from literature for a considerable number of species of the German flora.

Vegetative traits	Classification	Generative traits	Classification
VERTICAL EXPANSION		INDIVIDUAL REPRODUCTION	
canopy height	quantitative [m]	*age of first flowering*	coded [8 classes]
woodiness	coded [3 grades]	seasonal flowering period (time and duration)	quantitative [month of start/end]
branching	binary	*seasonal seed shedding period (time and duration)*	quantitative [month of start/end]
leaf distribution along the stem	coded [4 grades]		
shoot growth form	coded [6 grades]	*seeding frequency*	coded [4 classes]
leaf size	quantitative [mm]	*seed number per ramet*	quantitative
leaf mass	quantitative [mg]	seeds per dispersal unit	quantitative
specific leaf area (SLA)	quantitative [mm/mg]		
leaf phenology	coded [5 classes]		
leaf anatomy	coded [5 classes]	MATING SYSTEM / POLLINATION	
photosynthetical pathways	coded [3 classes]	mating system	coded [7 classes]
		mode of pollination	coded [4 classes]
LATERAL EXPANSION		pollinators	coded [8 classes]
clonal growth strategy	coded [2 classes]	chromosome number	quantitative [2n]
clonal growth organ (CGO)	coded [18 classes]		
role in plant growth (of CGO)	coded [3 classes]	DISPERSAL IN TIME	
life span of a shoot	coded [3 classes]	*seed bank longevity*	coded [3 classes]
persistence of connection between mother and daughter shoots	coded [3 classes]	DISPERSAL IN SPACE	
		type of dispersal unit	coded [5 classes]
daughter shoots / mother shoot × year	coded [4 classes]	**seed/dispersal unit mass**	quantitative [mg]
		seed/dispersal unit length	quantitative [mm]
extension of lateral spread (of CGO)	coded [4 classes]	**seed/dispersal unit width**	quantitative [mm]
		seed/dispersal unit height	quantitative [mm]
		seed/dispersal unit morphology	coded [11 classes]
HOLDING SPAN		releasing height	quantitative [m]
plant life span	coded [8 classes]	*terminal velocity*	quantitative [m/s]
individual life span	quantitative [years]	**attachment capacity**	coded [3 classes]
		buoyancy	coded [3 classes]
STRESS TOLERANCE		**capacity to survive digestion**	coded [3 classes]
aerenchyma	binominal	*dispersal type and vector*	coded [20 classes]
nutrition type	coded [5 classes]	*xero-/hygrochasy*	coded [2 classes]
mycorrhiza type	coded [4 classes]		
nitrogen fixation	binominal	GERMINATION AND ESTABLISHMENT	
		germination temperature	
DISTURBANCE RESPONSE		*germination requirement*	quantitative [opt/min]
life form	coded [8 classes]	*light requirement*	coded [4 classes]
physical defence structures	coded [4 classes]	*sensitivity to diurnal temperature*	
coded [3 classes]			
chemical defence mechanisms	coded [13 classes]	*amplitude*	coded [3 classes]
preference	coded [4 classes]	*dormancy*	coded [4 classes]
		time and period of seedling emergence	coded [3 classes]
		relative growth rate (RGR)	quantitative [mg/mg per week]

Fig. 1. Preliminary examples for the aggregation of data in the different database levels. One quantitative trait and one nominally coded trait were chosen to show general procedure. For the trait "seed number" (seed production per ramet or m^2) mean instead of ranges of average seed production are given in the "Scientific database", extreme values are ignored. In the "Practitioner's database" seed production is coded in 5 classes. For the trait "Mating system" the Basic and Scientific database are the same, in the Practitioner's database the species are classified according to the newest available literature and/or best available method. mean1, mean2 – range of average seed production per ramet; max2 – value for exceptionally large individuals; a – allogamous; praut – primary autogamous; apo – apomictic.

1. Basic database	Trait	Mean	Min.	Max.	Comment	References	Method	Country	Region
Geranium columbinum	Seed number			760		SALISBURY (1942)	estimated	UK	England
G. columbinum	Seed number	369			mean2	SALISBURY (1942)	estimated	UK	England
G. columbinum	Seed number	259			mean1	SALISBURY (1942)	estimated	UK	England
Glaux maritima	Seed number	5410	178.36	23135.8	per m^2	SALISBURY (1942)	estimated	UK	England
G. maritima	Seed number		0	286.7		SALISBURY (1942)	estimated	UK	England
Galium aparine	Seed number			1000	max2	KÄSTNER et al. (2001)	measurement		
G. aparine	Seed number	847				COUSENS & MORTIMER (1995)	unknown		
G. aparine	Seed number	50		500		KÄSTNER et al. (2001)	measurement		

2. Scientific database	Trait	Mean	Min.	Max.	Comment	References	Method	Country	Region
Geranium columbinum	Seed number	314		760	per ramet	SALISBURY (1942)	estimated	UK	England
Glaux maritima	Seed number	5410	178.36	23135.8	per m^2	SALISBURY (1942)	estimated	UK	England
G. maritima	Seed number		0	286.7	per ramet	SALISBURY (1942)	estimated	UK	England
Galium aparine	Seed number	50		500	per ramet	KÄSTNER et al. (2001)	measurement		
G. aparine	Seed number	847			per ramet	COUSENS & MORTIMER (1995)	unknown		

3. Practitioner´s database	Trait	Class	Comment
Geranium columbinum	Seed number	100–1000	
Glaux maritima	Seed number	1000–10000	per m^2
G. maritima	Seed number	100–1000	
Galium aparine	Seed number	100–1000	

1. Basic database	Trait	Value text	References	Method
Brachypodium pinnatum	Mating system	a	HEGI (1998)	unknown
Capsella bursa-pastoris	Mating system	praut	HURKA & NEUFFER (1997)	measurement
Nardus stricta	Mating system	apo	HEGI (1998)	unknown
N. stricta	Mating system		KNUTH (1898)	unknown
Poa nemoralis	Mating system	praut	KNUTH (1898)	unknown
P. nemoralis	Mating system	apo	HEGI (1998)	unknown
P. nemoralis	Mating system	apo	GREGOR & MATZKE-HAJEK (2002)	observation

3. Practitioner´s database	Trait	Value text
Brachypodium pinnatum	Mating system	allogamous
Capsella bursa-pastoris	Mating system	(primary) autogamous
Nardus stricta	Mating system	apomictic
Poa nemoralis	Mating system	apomictic

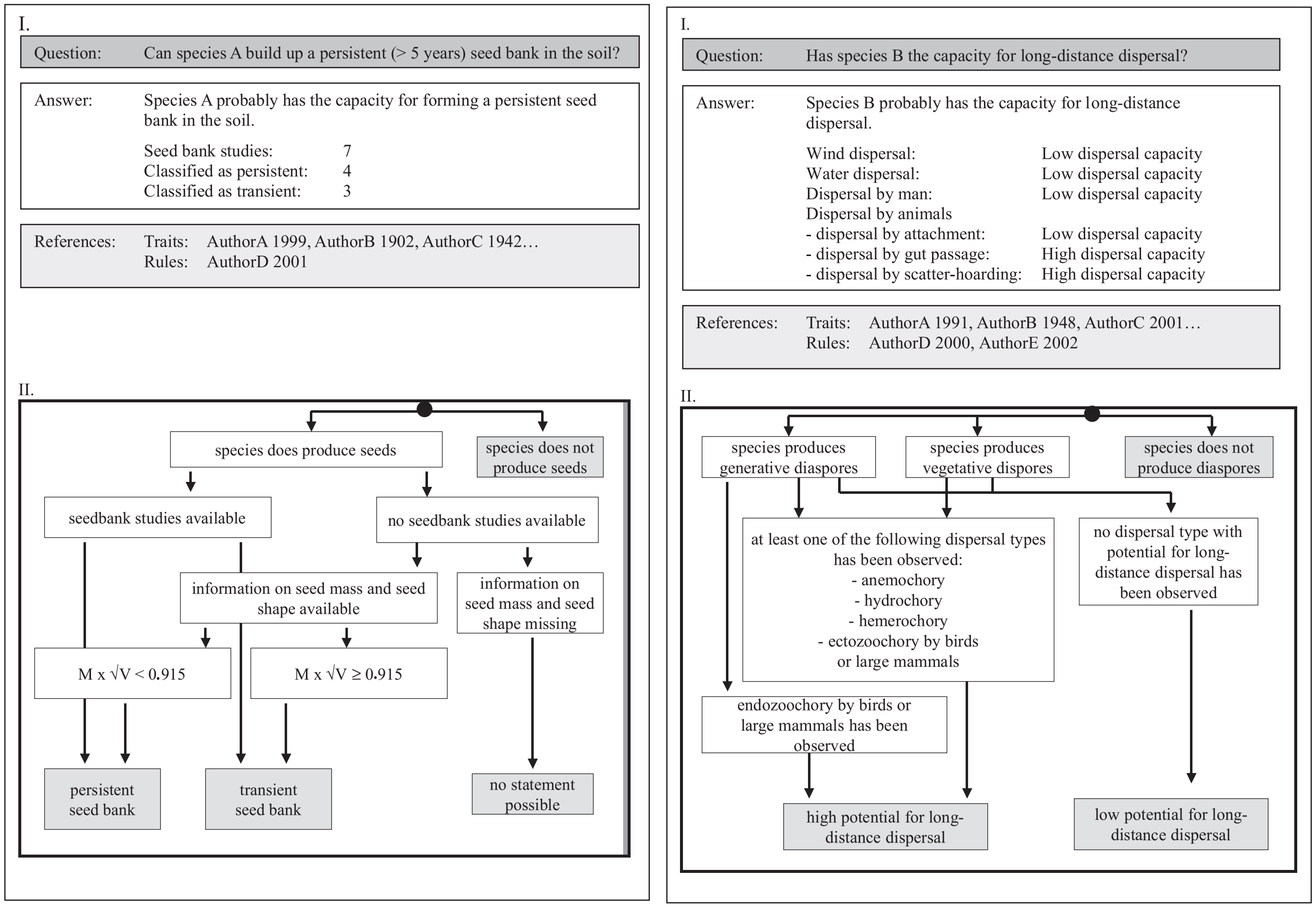

Fig. 2. Two preliminary examples for the counselling system. I –Possible questions with the answers, explanations and references as they would appear online. II – Dichotomous keys leading to the given ansvers. The keys are partly simplified, e.g. seed mass and seed shape are only valid indicators for seed longevity in habitats without below-ground disturbance. Limits of seed mass and seed shape for the classification of the seed bank type are taken from BAKKER et al. (2000).

BIOPOP includes 55 vegetative and generative plant traits (Table 1). The selection of traits is based on discussions at an international workshop on “Biological risk assessment and vulnerability analysis in plants” 1999 in Nettersheim, Germany (POSCHLOD et al. 2000). An interactive user-interface will enable the data to be readily used for extracting biological risk factors and for decision making in nature conservation. Taxonomic nomenclature is based on WISSKIRCHEN & HAEUPLER (1998).

Currently (April 2003), the basic database has been established and contains over 47,500 records on 51 traits for more than 4,700 plant taxa. Within this database, each value from each reference is stored in an individual record. Each record includes the reference as well as information on the method used to measure the data, on the country and the site of collection (if available). The given method (e.g. measurement, observation, derived of morphological traits ...) can be used as a quality criterion for the reliability of the data.

To faciliate handling and interpretation of the data, the aggregation of the data in two further database levels is planned (Fig. 1). These levels will give e.g. the mean of several quantitative values stored in the basic database or classify quantitative values into more easily interpretable coded classes. As the reference to each value is stored in the basic database, there will be no problem giving the cited authors with the aggregated data as well.

A further aim of the project is to develop expert system designed to answer questions regarding:

(1) ecological potentials of plant species to survive in a changing landscape (e.g. competitive ability – related to abandonment, long-distance dispersal – related to fragmentation);

(2) responses of species to habitat management;

(3) biological risk factors of plant species.

The answers to these questions will be calculated from the data in the database following simple algorithms based on an analysis of published studies and of long-term management and restoration projects in Germany (e.g. KAHMEN et al. 2002, MOOG et al. 2002, MOOG et al., unpubl.). Fig. 2 gives two preliminary ouputs for the expert system. Seed bank and dispersal potential were chosen as the first examples because dispersal in time and space are crucial factors in conservation issues as restoration management (BAKKER 1996) and conservation corridors (POSCHLOD & BONN 1998).

BIOPOP is closely connected to LEDA (“Life-history traits of the Northwest European flora”), an EU-project with similar objectives on an European scale started in November 2002 (see www.leda-traitbase.org).

In scientific papers it is often hard to publish raw data on ecological and life-history traits of plants. These data could be of great use for nature conservation and restoration issues, but are not accessible to other scientists, planners and public agencies. BIOPOP will represent an opportunity to make published and unpublished data on plant traits available on the Internet. BIOPOP is non-commercial and all authors will be cited with their data in data retrieval.

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