Do seed characteristics explain the change in frequency of arable weeds and ruderals in Germany ?

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Declining (1-4)

Adonis aestivalis
Aira praecox
Amaranthus retroflexus
Anthemis arvensis
Anthemis cotula
Apera spica-venti
Aphanes arvensis
Arnoseris minima
Bromus tectorum
Buglossoides arvensis
Bupleurum rotundifolium
Camelina sativa
Centaurea cyanus
Anagallis minima
Consolida regalis
Datura stramonium
Descurainia sophia
Digitaria ischaemum
Geranium dissectum
Holosteum umbellatum
Hyoscyamus niger
Lappula myosotis
Legousia hybrida
L. speculum-veneris
Lepidium ruderale
Matricaria chamomilla
Melampyrum arvense
Misopates orontium
Moenchia erecta
Myosotis stricta
Myosurus minimus
Odontites verna
Papaver argemone
Papaver dubium
Papaver rhoeas
Phleum arenarium
Ranunculus arvensis
Reseda lutea
Reseda luteola
Rumex maritimus
Scleranthus annuus
Setaria viridis
Sherardia arvensis
Silene conica
Silene noctiflora
Sisymbrium loeselii
Spergula arvensis
Spergularia rubra
Thlaspi perfoliatum
Valerinanella dentata
Verbena officinalis
Veronica praecox
Veronica triphyllos
Vicia tetrasperma
Vicia villosa

Stable (5)

Aethusa cynapium
Amaranthus chlorostachys
Anagallis arvensis
Arenaria serpyllifolia
Atriplex patula
Bromus sterilis
Capsella bursa-pastoris
Chenopodium album
Chenopodium gaucum
Chenopodium polyspermum
Chenopodium rubrum
Echinochloa crus-galli
Erophila verna
Euphorbia helioscopia
Fallopia convolvulus
Fumaria officinalis
Galeopsis tetrahit
Galinsoga parviflora
Galium aparine
Geranium pusillum
Juncus bufonius
Lactuca serriola
Lamium amplexicaule
Lamium purpureum
Lapsana communis
Malva neglecta
Matricaria discoidea
Medicago lupulina
Myosotis arvensis
Oenothera biennis
Poa annua
Polygonum aviculare
Persicaria lapathifolia
Persicaria maculosa
Sinapis arvensis
Sisymbrium officinale
Sonchus asper
Thlaspi arvense
Tripleurospermum inodorum
Veronica arvensis
Veronica hederifolia
Veronica persica
Veronica polita
Vicia angustifolia
Vicia hirsuta
Viola arvensis

Increasing (6-9)

Atriplex sagittata
Avena fatua
Chenopodium ficifolium
Conyza canadensis
Galinsoga ciliata
Heracleum mantegazzianum
Iva xanthifolia
Stellaria media

The Aim of the present study was to identify factors related to morphology (i), temperature requirements for germination (ii), and germination rate (iii; see below), which may explain the decline or increase of 110 arable weeds and ruderals (see left margin) in Germany.

Material and Methods:

The study was based on the dependent variable '**Change in frequency**' (Änderungstendenz, ELLENBERG (1992). Ellenberg assigned this trait to most species of the German flora, based on expert knowledge and the changes in the number of grid cells (Fig. 1, grid size approx. 30 km^2) occupied by the species' on a nationwide scale during the past few decades. This information was originally derived from a project for mapping the distribution of vascular plants in Germany (FlORKART, HAEUPLER & SCHÖNFELDER 1988,).

According to Ellenberg the value 1 denotes that 'a species is extinct or almost extinct', 5 means that 'no changes are detectable' and 9 denotes 'strongly increasing' species.

To identify possible causes for the change in frequency of arable weeds and ruderals the following independent variables were analysed following HÖLZEL & OTTE (2004):

i) Morphometric variables: Mass of 1000 seeds (**MASS**, g), length (mm), width (mm), and thickness (mm) of seeds;

ii) Temperature dependence of germination: lowest (**T-LOW**, °C), highest (**T- HIGH**, °C), amplitude (**T-AMP**, °C), optimal (**LOPT**, °C), and range of temperature optimum (**T-OPT**, °C) for germination;

iii) Germination rate: durability (**DUR**, days), and rate (**RATE**, seedlings per day).

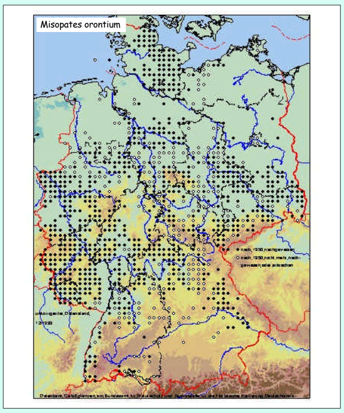

Fig. 1: Occurrence of Misopates orontium in FLORKART grid cells.

Results:

Only data sets for **T-AMP**, **T-OPT**, and **DUR** followed a normal distribution, while **T-HIGH**, **LOPT** and the morphometric variables seed mass, length, thickness and width of seeds showed skewed distributions (Fig. 2 and 3). For most of these variables, Spearman rank correlations were non-significant (data not shown).

However, **T-HIGH**, one of the variables describing the temperature dependence of germination, was significantly correlated (Spearman R=0.394, p<0.001) with the change of frequency. Species increasing in occurrence germinated at higher temperatures (Fig. 4) and – since most of the species already germinate at low temperatures - showed a broader temperature amplitude than declining species or species that showed no change in frequency.

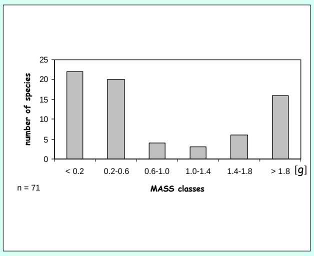

Fig. 2: Distribution of species numbers among **MASS** classes.

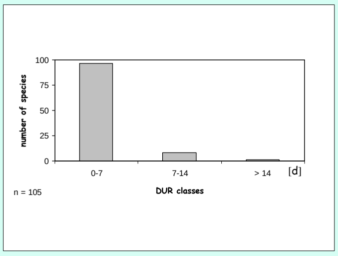

Fig 3: Distribution of species numbers among **DUR** classes.

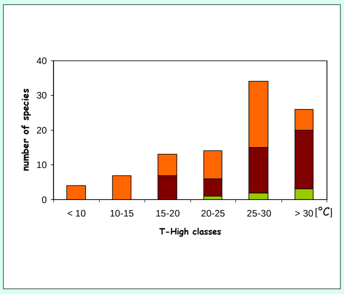

Fig. 4: Distribution of species among **T-HIGH** classes.
Declining sp. (red), stable (brown) and increasing (green) species.

Discussion:

Weak correlation between the studied variables and the change of occurrence, may be related to the fact that the variance across the data set was relatively low. For example, the majority of species (59 %) had very light seeds (< 0.6 g) and germinated very rapidly (mostly within one week). Thus, as an adaptation to their habitats, arable weeds and ruderals are characterised by low seed mass and fast germination.

However, species increasing in occurrence were consistently germinating at higher temperatures. Our data suggest that this temperature response may enable these species to germinate also at higher temperatures during summer. By this, they may enlarge their 'window of germination' and have the possibility to escape, e.g., herbicide application in spring by germinating in summer. The germination response to temperature is a species trait that may be subject to rapid evolutionary change due to intense selection pressure as shown for Chenopodium ficifolium (Otte 1991).

Seed characteristics such as seed longevity (Waldhardt et al. 2001), which also may have an effect on the changes in frequency, have not been considered here. Finally, current projects in our lab suggest that also population biological traits of species (e.g. Schubert et al. 2002) may be related to the change in frequency of short-lived species.

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