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Summary

The project **BINATS (Biodiversity-NATure-Safety)** was assigned and financed by the two Austrian Federal Ministries of Health and of Agriculture, Forestry, Environment and Water Management and was realized between 2006 and 2009.

The **BINATS biodiversity network** was developed as a tool for the **detection and evaluation of potential unintended effects of genetically modified plants (GMPs)** across the whole Austrian agricultural region. BINATS is the first **national monitoring and evaluation network** of the European Member States which is methodically focused on GMPs. It allows for estimating site-specific biodiversity-related risks of GMP cropping even in advance of their release. Moreover, it provides a database that represents the fundamental prerequisite for detecting long-term effects of GMPs.

The main tasks of BINATS were:

- Development and setup of a monitoring program of biodiversity-related effects of GMP cropping which should ideally be applicable for both, general surveillance and case specific monitoring.
- Selection of appropriate representative indicators to identify GMP specific effects on biodiversity, based on a cost-benefit calculation.
- Selection of test areas representative for the various soil types, climatic conditions and cultivation intensities in the Austrian agricultural region.
- Field tests of the developed monitoring design with respect to applicability and feasibility.
- Standardisation of the design for future inventories of biodiversity in the agrarian region.
- Collection of baseline data as a reference to enable the detection of future trends in agricultural biodiversity driven by GMP cropping or by other changes in agricultural practices.
- Implementation of a flexible monitoring system into which additional indicators can be integrated for an extended survey.
- Performance of a first nation wide risk assessment of special GMPs (in particular oilseed rape) based on the occurrence and frequency of related species, i.e. potential hybridisation partners.

Developing a monitoring program requires a series of fundamental decisions. As complex variables like biodiversity cannot be monitored directly, the first such decision concerns the selection of

appropriate indicators. Within BINATS, we searched for indicators that represent larger functional groups (e. g. primary producers, herbivores, pollinators) which are correlated to the diversity of as much un-surveyed taxonomic groups as possible and moreover respond sensitively and rapidly to changes in agrarian regions and which are particularly relevant to the GMP topic due to specific hypothesized risks. Based on a cost-benefit calculation, the following four indicators were finally chosen: **habitat structures** and **vascular plants** – which already have become standard elements of biodiversity monitoring programs in cultural landscapes – as well as **butterflies** and **grasshoppers**. Parameters like relevance as a biodiversity indicator, significance concerning GMPs, applicability in a long-term monitoring, effort of field work, acceptance of farmers (e. g. soil entrapments), state of knowledge, experts' availability, etc. were evaluated when selecting these animal indicators.

Setup of the BINATS monitoring program

In compliance with other national monitoring programs, the BINATS sampling design was nested into the raster of the Austrian forest inventory. Sampling took place within 625x625 m² raster cells in the Austrian oilseed rape and maize cultivation areas. Potential test areas (= raster cells) had to overlap with a raster point of the forest inventory and to have a share in non-forest habitats (cultivated land or grassland) of more than 80%. After environmental stratification, 65 such test areas were selected for both maize and oilseed rape cultivation areas. Following a visual evaluation concerning applicability, a final set of 50 areas was then chosen for each crop species.

Based on a methodical test in the field – transects *versus* circles – we decided to collect data on biodiversity indicators within ten circles (each with a radius of 20 m) that were randomly distributed across each test area. The benefits of this method are a standardized sampling area and hence sampling intensity, the avoidance of a sampling bias towards specific habitat structures, a higher efficiency of field work, a more precise spatial positioning and fewer conflicts with land-owners. Species richness of indicators vascular plants, butterflies and grasshoppers, individual numbers for the latter two groups as well as the abundance of potential hybridisation partners of oilseed rape were then recorded within these ten circles per test area. The inventory took place along a rectangular transect-cross with a side length of 20 m, oriented north-south and west-east, respectively.

In contrast to the taxonomic indicators, the inventory of habitat structures comprised the whole test area. The Red Lists of Austrian Endangered Biotopes (ESSL et al. 2002, 2004, 2008; TRAXLER et al. 2005a) were adjusted to the requirements of BINATS. The application of these lists proved to be feasible in field work. Field maps were digitised and stored in a Geographic Information System.

A detailed instruction of the BINATS inventory methodology is recorded in the published handbook (PASCHER, K., MOSER, D., SACHSLEHNER, L., HÖTTINGER, H., SAUBERER, N., DULLINGER, S., TRAXLER, A. & FRANK, T. 2009a: Kartierhandbuch zur Biodiversitätserfassung im Agrarraum: Gefäßpflanzen, Tagfalter, Heuschrecken, sowie Zuordnung von Landschaftsstrukturen zu ausgewählten Biotoptypen. Forschungsbericht im Auftrag der Bundesministerien für Gesundheit, Sektion II und Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien) which will shortly be published in English language.

Data analysis

Altogether, 900 vascular plant species - nearly one third of the entire Austrian flora - were detected across all 100 BINATS test areas. More than 11% of these are listed in the Austrian Red Book or in the species protection regulations of the Austrian Federal States. 53 different species of grasshoppers – 21 of which are endangered to different degrees – as well as 41 butterfly species – nine of them endangered – were found on the 1.000 cross-transects. The maximum number of vascular plants per test area (all ten cross-transects) was 212, the minimum 22. The species number of grasshoppers varied between 21 and one per test area. The butterflies showed a maximum of 15 species and a

minimum of none. On altogether 29.9% and 58.3% of the test circles no grasshopper, respectively butterfly species could be detected. The number of different habitat structures per test area varied between four and 38 with a maximum of 299 polygons as indicator for fine-grained landscapes.

With 587 detections in all 1.000 test circles the White Goosefoot (*Chenopodium album* agg.) proved to be the most frequent vascular plant species. The Common Chickweed (*Stellaria media*) was the next frequent one (518 detections) followed by the Creeping Thistle (*Cirsium arvense*) with 501 observations. The dominant grasshopper species was *Chorthippus biguttulus* (Nachtigall-Grashüpfer) with 188 detections. With 170 observations, *Pieris rapae* (Small White) proved to be the most frequent butterfly species.

Based on the occurrence and abundance of potential hybridisation partners, a first ecological risk assessment of GM oilseed rape was performed. The analyses showed that feral populations or volunteers of *Brassica napus* showed up in nearly three-quarters (71 out of 100) of all test areas. On average, oilseed rape could be recorded within 2.41 circles / test area. The plants mainly occurred as volunteers. In eight test areas (8%) feral oilseed rape populations could be observed along transport routes. The BINATS data hence additionally confirm that spillage during transport plays an important role for the establishment of feral oilseed rape populations.

One detection of maize plants (*Zea mays*) growing on a ruderal site was made in Burgenland. Its existence probably traces back to a spillage event during feeding of wild game. This assumption is supported by the absence of a maize field in the environs during the observation year. The existence of fertile maize plants outside cropping fields could be relevant for the coexistence of genetically modified, conventional and organic maize even in Central Europe.

On four test areas in Lower Austria weed beets from sugar beets (*Beta vulgaris* subsp. *vulgaris* var. *altissima*) could be detected. If GM sugar beets or fodder beets were cultivated for consumption the weed beets could function as transgene recipients as well as transgene sources because they reach the generative stage. No data concerning their frequency in Austria were present as yet.

Comparing the regional species numbers of vascular plants from the „Floristische Kartierung Österreichs“ or the diversity indices derived from them (“hot spot study”) with the species number of the BINATS test areas revealed a limited correlation of diversity patterns across scales. This important finding underlines that the assessment of biodiversity-related GMP risks on large spatial scale might not provide satisfying results in fine-grained cultural landscapes. This means that a **small scaled inventory as done in BINATS is mandatory for the evaluation of GMPs.**

Habitat structure diversity and species number of vascular plants, butterflies and grasshoppers were positively correlated which implies that particular attributes of a landscape (e. g. habitat diversity, cultivation intensity) affect different groups of organisms in a similar way. For all taxa a positive correlation between habitat structure diversity, landscape patch shape complexity as well as share in grassland habitats could be detected. On the contrary, all taxa showed a negative correlation with the proportion of cultivated land. Surprisingly, numbers of vascular plants were hardly correlated to soil type diversity, likely due to the homogenising effect of cultivation. Such homogenisation of the floras and faunas of once different habitats often results from intensive forms of cultivation that include, e. g. drainage, sowing, herbicide application and mowing. Concerning climatic gradients an unexpected negative correlation of vascular plant species number with decreasing mean annual temperatures was found. Again, this effect obviously results from gradients in land use intensity that interfere with climatic gradients. Indeed, land use intensity rises with climatic favourability hence (over)-compensating potential positive effects of climate on biodiversity. However, this trend was less pronounced for grasshoppers. Butterflies showed a hump-shaped relationship to climate with higher species numbers at both the cold and warm margins of the (summer) temperature gradient.

Résumé

The BINATS monitoring design was particularly developed to identify and assess potential effects of GMPs on the biodiversity of agrarian regions, but it can also be applied for a general biodiversity monitoring in agricultural areas as well as for OEPUL-evaluations.

BINATS has created the basis for a long-term observation network of plant and animal biodiversity in the Austrian agricultural regions. As the developed monitoring design considered a cost-benefit calculation regular repetition should well be feasible. The BINATS design meets the requirements of a flexible monitoring system into which additional indicators and their particular inventory needs can easily be integrated if necessary.

BINATS moreover provides extensive data on habitat structures and the diversity of three different groups of organisms across the whole Austrian agricultural regions which can also be used for the general biodiversity research. In case of a GMP release extensive standardised baseline data on biodiversity are now available together with a representative set of adequate test areas. To be able to detect changes in biodiversity, time series and repeated revisions of the BINATS data are needed. Such time series will allow for distinguishing between GMP specific and general trends in agricultural biodiversity. It is recommended to perform these repetitions in a rhythm of five years.