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Establishing an amphibian monitoring program in two protected areas of Romania

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Abstract. Aquatic habitats and amphibian species were inventoried during 2004-2005 in two nearby protected areas in Romania. The Retezat National Park and the nearby Hateg Geopark cover together an area of 1400 km^2 along an altitudinal range between 400-2500 m. We inventoried over 200 aquatic habitats and identified 11 amphibian species. We selected non-randomly 14 sites for monitoring based on several criteria as accessibility, likely permanence on medium term, representative coverage throughout the protected areas, and high amphibian species richness. We propose a low and a medium cost amphibian monitoring programs.

Introduction

The widespread decline of amphibian populations and the multitude of factors causing this (Green, 2003; Kiesecker et al., 2001; Stuart et al., 2004) suggest a need to monitor amphibian populations (Dodd, 2003). Since factors affecting population dynamic may have both natural and anthropogenic origins, monitoring programs are required to track changes in populations, communities, and habitat quality to better identify the causes of their changing in time (Pechmann, 2003).

Two elements are crucial to ensure the success of a monitoring program: well-defined objectives and science-based data from which reliable inference can be made (Pellet and Schmidt, 2005). Information and data obtained from regular monitoring programs can be enhanced, if data from pristine or low impact areas are available and can be used as a reference.

Romania still has large areas of relatively pristine habitats that can offer useful information for a continental scale amphibian monitoring program. Baseline information on the status and trends of Romanian amphibians is sparse. To fill this gap we surveyed the aquatic habitats from two nearby protected areas from Romania. We focused on two objectives: (1) gather baseline data through the inventory of habitat availability and use by amphibian communities, and (2) select aquatic habitats and identify species for the establishment of a medium-term (5-10 years) monitoring program.

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Materials and methods

Study area. - Retezat Mountains National Park (RNP) and the nearby Hateg Geopark (HG) together cover an area of 1400 km^2 ranging in elevation between 400-2500 m a.s.l. Several arguments point in favor of establishing a monitoring program in these areas. RNP is one of the least human-affected protected areas in Central Europe, with dense forests including old-growth stands. It is the oldest national park in Romania, established by law in 1935. Glacial and cryonival relief are extremely widespread allowing lakes to form in the deeper parts of moraines. Fifty-eight permanent glacial lakes were recorded at elevations between 1700-2300 m. The Retezat Mountains have the highest rainfall and runoff in the Romanian Carpathians. Their glacial lakes are some of the least impacted freshwaters in Europe (Curtis et al., 2005). HG borders RNP to the north, and was established as a protected area in 2004. It is located at a lower elevation and has a highly diverse rural landscape (e.g., hayfields, forests, orchards, agro-ecosystems, sparsely disseminated rural areas). Together the two parks contain a variety of aquatic habitats, ranging from low elevation reservoirs, irrigation canals, fens and marshes to high elevation alpine lakes and temporary ponds. Of the 19 species of amphibians inhabiting Romania, 11 species occur in the two parks (Cogălniceanu et al., 2001).

Habitat and species inventory. - We began an inventory of aquatic habitats in 2000 in RNP and in 2004 in HG. A prior identification of permanent aquatic habitats was based on detailed 1:25.000 or 1:5.000 topographic maps. We measured geographical coordinates, elevation, area and average depth, water pH, conductivity, temperature, and transparency for each aquatic habitat. We also recorded the presence/absence of aquatic predators such as insects and insect larvae, leeches, and fish. We characterized the surrounding terrestrial habitat in terms of substrate, vegetation cover and human activities.

- Species inventory in the two parks was based on repeated visits and the combination of a variety of census techniques (see Dodd et al., in press) in order to maximize the detection of species, as recommended by Ryan et al. (2002).

Species accumulation curves are good estimates of the amount of sampling required for a complete species inventory within a certain area. We computed species accumulation curves using

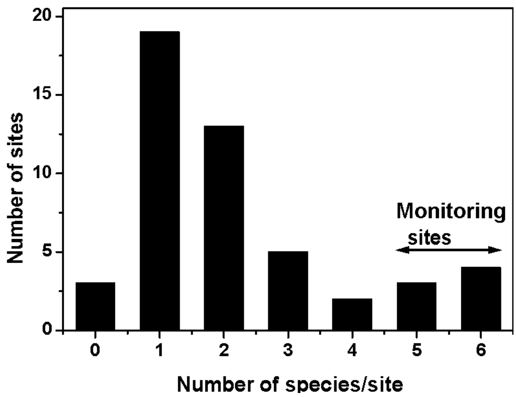

Figure 1. Species richness of the aquatic habitats inventoried in Haţeg Geopark.

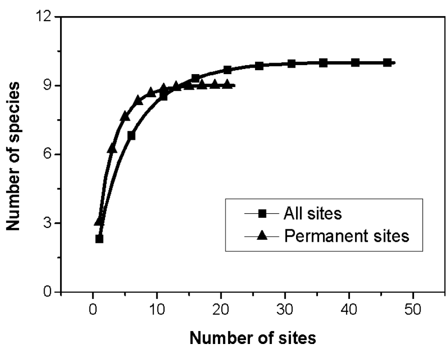

Figure 2. Cumulative species accumulation curves for amphibians inventoried at Haţeg Geopark: for all of the sites visited (where each site was considered as a single data point despite the multiple visits made), and for the six permanent sites (where each visit to a particular site was considered as an independent event).

EstimateS 5.0 (Colwell, 1997). By randomizing sample order (100 randomizations) and computing the mean species richness estimate for each sample accumulation level, EstimateS removes the effect of sample order and generates a smooth species accumulation curve.
We assembled baseline data for the species identified for monitoring, including estimates of population size and reproductive effort and success. A database was begun with digital images for individual identification based on the dorsal (e.g. in *Rana temporaria*) or ventral pattern (e.g. in *Bombina variegata*) (Plăiaşu et al., 2005), for mark-recapture population estimates.

Results

Aquatic habitat inventory

We inventoried aquatic habitats throughout the major parts of the two parks: 46 in HG and 156 in RNP. We selected 14 sites for monitoring of which six were located at low elevations (HG), and eight sites above the tree-line (RNP). The selection was non-random, based on several criteria: accessibility, likely permanence over the course of the study (i.e. no immediate threat of destruction), representative coverage throughout the protected areas, origin and types of habitats, and high amphibian species diversity (table 1; fig. 1).
Apart from the permanent sites selected for monitoring, we selected an alpine valley in the RNP (Judele Valley, elevation range 2000-2170 m a.s.l., lat. 45.35 N, long. 22.8 E) for a detailed analysis of habitat availability and use by amphibians. We inventoried 23 aquatic sites (including clusters of ponds), in which three species of amphibians were found: *Rana temporaria* (present at 52% of the sites), *Triturus alpestris* (18.5%) and *B. bufo* (9.2%).

Amphibian species inventory

Ten amphibian species and a species complex occur in the two protected areas: *Triturus vulgaris, T. alpestris, T. cristatus, Salamandra salamandra, Bombina variegata, Hyla arborea, Bufo viridis, B. bufo, Rana dalmatina, R. temporaria* and *R. esculenta* complex.
Species detectability at the six sites selected for permanent monitoring in HG varied according to species, among sites, and time of year from between 0 (i.e., no species recorded) and 100% (i.e., all known species recorded during one visit) with an overall mean value of 45%.
The species accumulation curves computed for HG showed that species richness reached an asymptote (i.e. the inventory was completed) more rapidly when based on repeated visits to sites selected for permanent monitoring, when compared to all of the aquatic habitats sampled (fig. 2). Monitoring the selected sites is thus more informative in terms of detecting shifts in amphibian community richness and composition.
Since multispecies surveys are usually inefficient for rare species (Pellet and Schmidt, 2005), we selected three species with wide range and high detectability for intensive monitoring at a population level (fig. 3). *Bombina variegata* is the most widespread species in the lowlands, but is also expanding into the alpine area. *Rana temporaria* is widespread between 600-2200 m, and the only species reaching high elevation lakes. *Triturus alpestris* is rather abundant but due to lower dispersal abilities, has rather isolated populations, especially in alpine

Table 1. Elevation and physico-chemical parameters of the aquatic sites investigated in Retezat Mountains National Park (RNP) and Hateg Geopark (HG). Only the results from 2004-2005 are presented below, and only high elevation site information is included for RNP. The values given are the mean ± one standard deviation and, in parentheses, the minimum and maximum values.

Protected area	Elevation (m)	pH	Conductivity (μS)	Water temperature (^{0}C)	Species richness
RNP Alpine area, N=59	2080 ± 80 (1920-2260)	7.04 (4.73-8.46)	12.8 ± 5.4 (4.5-38)	13.9 ± 4.2 (2.4-26)	Only three species present
HG Selected sites, N=6	490.6 ± 86.9 (384-594)	7.43 (5.42-8.47	185 ± 156 (75 – 465)	20.5 ± 1.5 (14.5 – 25)	5.66 ± 0.5 (5-6)
HG Temporary ponds N=40	472 ± 117 (337-813)	6.76 (6.08-7.54)	251 ± 149 (86-678)	23.1 ± 4.6 (12-34)	1.65 ± 1.1 (0-5)

areas. We estimated population size for these three species in all permanent monitoring sites, as reference data.

Discussion

Our proposed monitoring program is facing two important sources of variation: selecting areas for surveying that will permit inference to the entire area of interest, and detection of the species selected for monitoring. Due to the inconspicuous behaviour of amphibians, the use of abundance and site occupancy estimators is highly recommended (MacKenzie et al., 2002).

One of the major issues is identifying the basic demographic unit for monitoring population trends, i.e. if it should be an individual pond or a cluster of local ponds. We agree with Petranka et al. (2004) that pond populations only several tens or hundred meters apart should be treated as subpopulations of the same monitoring unit. Thus, several of the sites selected for monitoring consist of clusters of up to six different ponds.

Large monitoring programs may involve high costs still the resulting data can often be biased. Our approach towards establishing a monitoring program is more realistic and practical, emphasizing feasibility. It is difficult to convince decision makers of the utility and importance of a long-term monitoring program. Recently, two long-term amphibian monitoring programs in Europe were stopped due to lack of funding (Hachtel et al., 2005, Jehle et al., 1997). One of our concerns was how to avoid a similar outcome. The solution seemed to be a low-cost program, with reasonable data output, that would justify its continuation. The difficulty was in deciding the minimal threshold of effort required for generating statistically robust data. Finally, low-cost (with minimal coverage) and medium-cost (which would generate more high quality data) scenarios were proposed.

We suggest that the project should be evaluated after five years to assess its utility and reconsider its goals. An additional 15-45 sites each year (depending on funds available) randomly selected from previously inventoried sites will be monitored each year besides the permanent sites. Minimum sampling effort will involve one experienced investigator-hour for a permanent site, with at least three visits annually.

The low-cost scenario will involve monitoring only permanent sites and an additional randomly chosen 15 sites (five at high elevations in RNP and 10 in HG). Our approach would include each temporary aquatic site in the inventory at least once every 4-5 years. The medium cost approach will involve sampling an additional 30-35 randomly chosen sites (with 10-15 in RNP). From the variety of inventory techniques available, we recommend time-constrained visual surveys and dip-netting. This means that each site will be sampled every 2-3 years. Since temporary

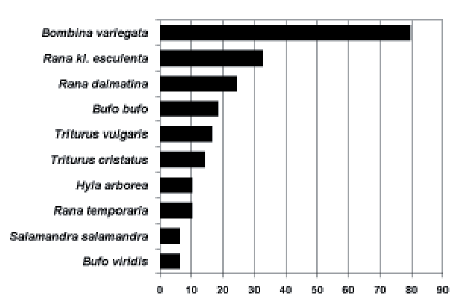

Figure 3. Frequency of occurrence of amphibians within the Hațeg Geopark.

ponds are important but unpredictable habitats for amphibians (Griffiths, 1997; Cogălniceanu, 1999), regular monitoring might provide data too variable for reliable trend analyses.

Expected outcomes of the monitoring program

There are several important outcomes of the proposed monitoring program, including the opportunity to detect climate changes at high elevations in RNP due to global weather changes, and the resulting shifts in distribution of *Bufo bufo, Bombina variegata* and *Triturus alpestris* at higher elevations. We expect an increase in human pressure or changes in human activities at lower elevations in HG due to the EU Common Agriculture Policy that will affect rural communities. The amphibian monitoring program could provide a much needed and rapid assessment of the resulting environmental impact. It will also provide support for the protected areas management plans (Semlitsch, 2000), currently being prepared for HG and awaiting revision for RNP.

Monitoring activities usually yield a low publication output and are thus unattractive to the highly competitive scientific community. The baseline data gathered during the proposed monitoring program can identify and support the establishment of directed research projects and thus become more attractive. Finally, the approach outlined in our proposed monitoring program could be extended to three other large protected areas linking the Danube Valley with the Southern Carpathians (Iron Gates Natural Park, Cerna-Domogled National Park and Grădişte-Cioclovina Natural Park).

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