# Conservation Issues

## Biodiversity in Hungary: Advantages and Limitations of Taxonomically Complete Faunal Inventories

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**ABSTRACT:** Although inventories are the first step in biodiversity assessment and in many other approaches to biological conservation, taxonomically complete inventories are rarely conducted. There are two main types of inventories—those that are ecologically designed, wherein the sampling is repeatable, and search-based inventories, wherein it is not. I analyzed lists from search-based inventories of four Hungarian reserves. Because they included unpopular and difficult-to-identify taxa, the inventories were closer to complete, in taxonomic terms, than most inventories. Based on the geographical location of the reserves, and the repetition of one inventory, I estimated the number of expected new species in Hungary to be 3,400. This number, however, was strongly challenged by several experts. For example, 5,000 new species of Diptera are expected to be recorded in Hungary. Thus, I concluded that the inventories of the Hungarian reserves are incomplete. The limitations of search-type inventories include nonrepeatability due to lack of predetermined and documented sampling protocols. The advantage of searching is that it provides the most taxonomically complete inventory.

*Index terms*: conservation, inventory, invertebrates, reserves, species richness

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## INTRODUCTION

Conservation biology, the science of the preservation of biodiversity, became a major discipline in the 1980s (Meffe and Carroll 1994). Recent studies show that ecosystem stability, integrity, and processes are significantly related to biodiversity (e.g., Angemeier and Karr 1994, Naeem et al. 1994, Tilman and Downing 1994, McGrady-Steed et al. 1997, Tilman et al. 1997). A simple and widely used measure of biodiversity is species richness. Unfortunately, reliance on species richness often leads to oversimplification. For example, Hughes et al. (1997) estimated that there are 220 genetically distinct populations per species. Thus, ignoring genetic data may lead to significant underestimation of biodiversity loss. The available data, however, especially those from large geographic areas or diverse taxa, contain almost entirely species-level observations, mainly presence/absence data.

One of the most important tasks of conservation biology is to conduct inventories. An inventory is a list of biological entities from a particular site or area (Stork and Davies 1996). These entities may be genes, individuals, populations, habitats, and so on, though species lists are most commonly compiled. In this paper I focus on faunal inventories, where the entities are taxonomic units—animal species and subspecies.

A faunal inventory can be conducted in one of several ways. Goals and available resources will determine the appropriate method. Stohlgren et al. (1995) listed five approaches: (1) systematic sampling, which produces geographically broad information; (2) stratified random sampling, which results in ecologically complete information; (3) searching, which tends to be taxonomically complete; (4) gradient studies, where species-environment relationships are described; and (5) the assessment of indicator species, which might be used to infer ecosystem integrity, processes, and so on. All approaches have advantages and limitations. One important difference that distinguishes searching from the other methods is that generally a search cannot be replicated. All of the other methods apply various sampling techniques, and it is usually possible to repeat samples (if there was a sampling protocol and it was documented in detail). Hence these approaches can be called ecologically designed inventories. When a simple search for new species in an area is conducted according to an investigator's best knowledge, repeatability is negated.

An ecologically designed inventory, designed for the estimation of species numbers and abundances through predetermined sampling protocol for an area of

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many square kilometers, requires much more time and money than a search, which focuses merely on the presence/absence of species (cf. Stohlgren et al. 1995). The inclusion of major unpopular and difficult-to-identify animal taxa in an inventory may also require that greater resources be applied to the inventory effort (Lawton et al. 1998). Faunal inventories, therefore, usually exclude unpopular groups such as most invertebrates (Hammond 1992, Stohlgren and Quinn 1992, Stork 1994, Stohlgren et al. 1995). However, inventories of Hungarian reserves compiled to date are better in terms of taxonomic coverage than many other inventories. For example, Hanski and Hammond (1995) reported ca. 870 beetle species for a boreal forest (Finland), and ca. 1,500 species for an English deciduous forest; but in the forested Bükk National Park in Hungary, almost 3,000 beetle species were found (Mahunka 1993, 1996). The scientific organizers of inventories in Hungary have made serious efforts to include unpopular and difficult-to-identify animal taxa such as Collembola, Diptera, Hymenoptera, or Acari in addition to popular taxa such as vertebrates, Lepidoptera, and Coleoptera (Moskát et al. 1993).

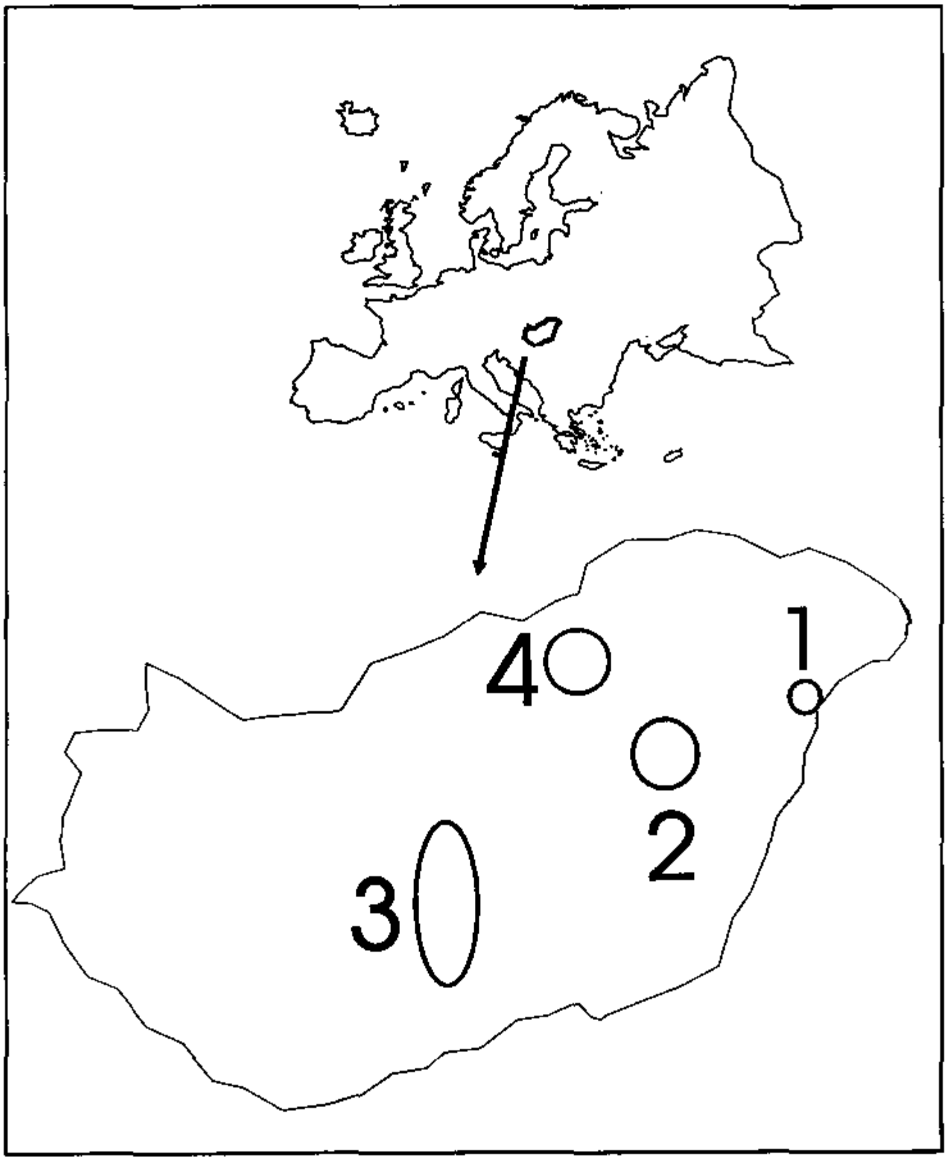


**Figure 1. Map of Hungary and the locations of studied reserves. 1: Bátorliget Nature Reserves, 2: Hortobágy National Park, 3: Kiskunság National Park, 4: Bükk National Park. See Table 1 for additional information about the reserves.**

The objectives of this paper are to describe the main characteristics of the faunal inventories of several Hungarian protected areas, to evaluate the costs and benefits of search-based inventories (for example for estimating total animal species richness of Hungary), and to evaluate the repeatability of searches based on inventories of the Bátorliget Nature Reserves from the 1940s and 1980s.

## STUDY AREAS AND METHODS

Hungary has nine national parks and about 200 nature reserves. Complete biotic inventories, where most major animal taxa were included, are available already from three of the national parks (Hortobágy NP, Kiskunság NP, and Bükk NP) (Mahunka 1981, 1983, 1986, 1987, 1993, 1996). Inventories have been conducted in four other national parks (Aggtelek NP, Fertő-Hanság NP, Körös-Maros NP, and Duna-Dráva NP). I analyzed faunal lists from three national parks (Hortobágy, Kiskunság, and Bükk) and the Bátorliget Nature Reserves (BNR), from which complete inventories are also available (Table 1, Figure 1). I evaluated two inventories of BNR—the first was conducted in the 1940s (Székessy 1953), then was repeated in the late 1980s (Mahunka 1991)—which allowed me to test for the repeatability of search-based inventories. The primary aim of each inventory was "to establish the species composition of plants and animals (natural gene bank) of the territory under investigation" (Mahunka 1981: 10). The emphasis was on invertebrates, mainly insects (Table 2), because they are the major contributors to species richness.

I studied the potential usefulness of these lists to make an estimate of the total number of animal species in Hungary (total biodiversity). The number of newly described taxa and the number of new records for Hungary were evaluated based on the spatial and temporal distribution of the inventories. There are five major biogeographic regions in Hungary, but the four inventories (plus one repeate inventory) cover only two of the five regions. Three

Table 1. Description of studied national parks and reserves in Hungary (NP = national park, NR = nature reserve).

| Name | Type | Total Area (ha) | Habitat | Years of Inventory |
|---|---|---|---|---|
| Bátorliget NR | 3 reserves | 374 | forest, marsh, pasture | 1948–1950 and 1988–1990 |
| Hortobágy NP | 1 large and 6 satelite reserves | 43,550 | dry alkaline meadows, marshes, few remnant forest patches | 1974–1976 |
| Kiskunság NP | 18 reserves | 39,938 | marshes, swamps, forests, dry alkaline meadows, sand dunes | 1977–1980 |
| Bükk NP | 1 reserve | 38,775 | deciduous forests | 1981–1985 |

inventories are from the Great Plain region (Hortobágy NP, Kiskunság NP, and BNR), and Bükk NP is in the Northern Mountain region. Since the Great Plain region is the largest one, three study sites did not oversample this region. However, three other regions in the western part of the country lacked complete inventories. One way to roughly estimate the number of expected species of the studied taxa in Hungary is simply to extrapolate based on the numbers of newly described taxa and new records for Hungary.

## RESULTS

During the five inventories in the four areas of the two biogeographic regions, 174 new taxa were described and 1,081 species new to Hungary were identified (Table 3). Therefore, the number of species in the surveyed taxa increased by 1,255. Thus I estimate that the three other biogeographic regions have the potential to add about 1,880 new species to the Hungarian species list (1,255 / 2 = 628; 628 x 3 = 1,883).

The species number of an area varies not only in space but in time. However, extensive and complete inventories are rarely repeated. An exception was at BNR, where 40 years after a first inventory, the second inventory added 1,842 new taxa in the 15 common major taxonomic groups (Table 2)—46% of the number of taxa recorded in the first inventory (Mahunka 1991). The number of new species for Hungary and newly described taxa is summed to 4.1% of the total species number of the first inventory in the BNR. Thus, a second survey of the other reserves should add about 303 new species for Hortobágy NP, 362 for Kiskunság NP, and 347 for Bükk NP.

In the taxa surveyed, Hungary has 34,316 animal species (Table 2). The inclusion of the other biogeographic regions could increase the number of animal species in Hungary by 1,880 to a total of 36,200 species. Furthermore, repeting the inventories could add another 4%, resulting in a total increase of 3,400, for a total species list of 37,700.

## DISCUSSION

Species lists are the first steps in biodiversity assessment, but further steps are necessary for spatial and temporal replicability, including an exact documentation of sampling procedure and results. Debinski and Humphrey (1997) suggested an integrated approach to biodiversity assessment that requires a priori selection of taxa, sampling sites, and methods.

According to current thought, it is not possible to assess biodiversity based on search-type inventories; because extrapolation usually needs quantitative data (Hone 1991). I examined whether the Hungarian search inventories could be used to extrapolate information on biodiversity in Hungary by addressing two questions.

### *How complete are the search inventories?*

The lack of data from a third biogeographic region prohibits the evaluation of possible variations in space, but the repeated inventorying at BNR makes it possible to evaluate the similarities of inventories over time. The number of new species recorded for the BNR in the second inventory was 46% of the first survey. The strikingly small overlap may be due to environmental changes over the 40-year period, or it may be due to the limits of inventories. Although several signs of vegetation degradation were detected (Standovár et al. 1991), no large-scale environmental changes have occurred between the two surveys. Thus, the differences may be attributable to collecting methodology and personnel factors. Considering methodology first, Merkl (1991) found that 49% of the Coleoptera species overlap between the two surveys. He argued that this great difference was simply the result of different sampling methods used. For example, during the first inventory, collectors did not use pitfall traps and used different lamps for night collecting; the collectors of the second survey did not sift bird nests and did not encounter nocturnal mass swarming (Merkl 1991).

Considering personnel factors, the BL'90 column in Table 2 reflects at least two possible reasons for differences. First, the willingness and ability of experts to participate in data collecting may vary. For example, the second inventory of BNR almost doubled the bird species list, although such a large increase is unexpected. However, during the first inventory the experts spent only one week in the field, in June 1952. The second inventory included the census of birds along a 2,500-m line transect five times over the years 1989 and 1990, and a night observation. In the case of relatively unpopular and scarcely known taxa, the knowledge of the field observer/collector and of the identifier may also cause differences in species number. Sec-

**Table 2. Major animal taxa that were included in at least two of the inventories of Hungarian parks and reserves. "Hungary" = total number of species in Hungary. The other columns refer to the individual inventories" BL'40 = Bátorliget NR in the 1940s, BL'80 = Bátorliget NR in the 1980s (no. of new taxa, % of 1940s survey), HNP = Hortobágy NP, KNP = Kiskunság NP, BNP = Bükk NP. (Modified from Mahunka 1987, p 10. Note that the source was compiled before the completion of several inventories. As a consequence, some species numbers in the "Hungary" column are less than the number in an inventory column.)**

| Taxon | Hungary | BL'40 | BL'80 | HNP | KNP | BNP |
|---|---|---|---|---|---|---|
| Monogenea | 251 | 0 | 0 | 114 | 45 | 0 |
| Cestoda | 201 | 0 | 12 | 101 | 125 | 0 |
| Free-living Nematoda | 1050 | 51 | 149 | 105 | 63 | 147 |
| Acanthocephala | 23 | 1 | 3 | 10 | 8 | 0 |
| Rotatoria | 600 | 143 | 108 | 65 | 0 | 0 |
| Oligochaeta | 60 | 0 | 32 | 12 | 1 | 0 |
| Hirudinoidea | 30 | 1 | 10 | 0 | 1 | 0 |
| Gastropoda | 140 | 66 | 69 | 52 | 72 | 101 |
| Lamellibranchiata | 20 | 2 | 4 (2, 100%) | 7 | 5 | 5 |
| Tardigrada | 60 | 0 | 11 | 0 | 13 | 0 |
| Aquatic crustacea | 120 | 35 | 40 (18, 51%) | 0 | 65 | 25 |
| Entomostraca | 200 | 40 | 0 | 86 | 0 | 0 |
| Diplopoda | 160 | 17 | 18 (4, 24%) | 6 | 9 | 0 |
| Chilopoda | 30 | 13 | 11 (2, 15%) | 13 | 9 | 0 |
| Collembola | 110 | 10 | 73 (65, 650%) | 63 | 33 | 0 |
| Ephemeroptera | 50 | 0 | 2 | 4 | 3 | 0 |
| Odonata | 63 | 20 | 25 (5, 20%) | 39 | 45 | 0 |
| Orthoptera | 160 | 40 | 51 (18, 45%) | 53 | 63 | 80 |
| Dermaptera | 7 | 0 | 3 | 2 | 0 | 0 |
| Mallophaga | 100 | 0 | 45 | 0 | 20 | 9 |
| Thysanoptera | 180 | 1 | 73 | 33 | 47 | 101 |
| Heteroptera [a] | 835 | 141 | 151 (102, 72%) | 202 | 377 | 0 |
| Homoptera [a] | 1,125 | 50 | 97 | 231 | 132 | 206 |
| Neuroptera | 45 | 1 | 28 | 19 | 31 | 53 |
| Megaloptera | 2 | 0 | 0 | 1 | 1 | 3 |
| Mecoptera | 3 | 0 | 2 | 2 | 1 | 0 |
| Raphidioptera | 10 | 0 | 0 | 2 | 2 | 5 |
| Coleoptera | 6,000 | 1,578 | 1,494 (486, 28%) | 1,906 | 2,603 | 2,875 |
| Trichoptera | 180 | 1 | 33 | 23 | 23 | 109 |
| Lepidoptera | 3,260 | 850 | 826 (270, 32%) | 866 | 1,797 | 1,854 |
| Siphonaptera | 61 | 0 | 0 | 11 | 0 | 25 |
| Diptera | 5,100 | 221 | 522 (428, 194%) | 1,266 | 1,047 | 1,358 |
| Hymenoptera | 10,000 | 834 | 635 (396, 47%) | 964 | 1,345 | 1,067 |
| Araneae | 1,100 | 165 | 182 | 221 | 174 | 0 |
| Pseudoscorpiones | 30 | 0 | 10 | 11 | 0 | 0 |
| Acari | 1,500 | 0 | 291 | 329 | 307 | 277 |
| Pisces | 64 | 3 | 0 | 22 | 32 | 0 |
| Amphibia | 15 | 9 | 9 (0, 0%) | 10 | 11 | 13 |
| Reptilia | 15 | 6 | 7 (1, 17%) | 4 | 10 | 10 |
| Aves | 329 | 43 | 71 (46, 93%) | 215 | 246 | 137 |
| Mammalia [a] | 77 | 28 | 0 | 38 | 48 | 23 |
| **Total** | **34,316** | **4,370** | **5,097 (1842,46%)** | **7,384** | **8,822** | **8,464** |

[a] Not all the taxa in some major groups were surveyed in all inventories.

ond, the willingness and financial abilities of organizers to involve experts with the inventory also varied; the financial support for these inventories was extremely small (only a few thousand U.S. dollars).

The density of efforts is another important factor. The species number at Bátorliget NR and the three national parks is of the same magnitude, however, the area of the reserves is not. That is, the intensity of inventory on a given area also influences the composition and size of the final species list.

*How reliable is the estimate of 3,400 new species for Hungary?*

I asked several curators of the Hungarian Natural History Museum who have participated in the faunal inventories for many years to predict the number of new species for Hungary that could be discovered in the future for their taxa. I then compared their estimates with my calculation of 3,400.

There were great differences between popular and unpopular (usually difficult-to-identify) taxa. For vertebrates, there have been very few new species recorded, although hundreds of amateurs, mainly bird and bat watchers, search for new species. Even for the hyper diverse taxa of Coleoptera (6,000 species known) and Lepidoptera (3,500 species known), only a few hundred new species are expected (O. Merkl and L. Ronkay, Hungarian Natural History Museum, pers. com.).

In contrast to the popular taxa, the expected number of new species for Hungary in unpopular taxa is much larger. A detailed survey of the distribution of Palearctic Diptera species revealed that at least 5,000 new species are still to be recorded in Hungary (L. Papp, Hungarian Natural History Museum, pers. com.). A rough estimate of the number of expected Acari species is 3,000 (S. Mahunka, Hungarian Natural History Museum, pers. com.).

Although more detailed analysis is needed, it is very significant that the main differences in the number of expected species are between popular and unpopular taxa and not between taxa with many and few species. The generalization that the numbers of expected and recorded taxa in an area are correlated seems to be invalid. Consequently, in future surveys investigators should be careful to involve the services of specialists with knowledge of unpopular taxa, for which the number of expected species seems to be an order larger than it is for popular taxa. This precaution is likely to have a greater impact on increasing the taxonomic coverage of the inventory than adding experts on popular taxa would.

**Table 3. Number of taxa, new records for Hungary, and new taxa described for the four studied Hungarian parks and reserves. Number of new taxa includes both species and subspecies.**

| Name of Area | No. taxa | No. new Records | No. New Taxa |
|---|---|---|---|
| Bátorliget NR 1940s | 4,370 | 67 | 17 |
| Hortobágy NP | 7,384 | 345 | 87 |
| Kiskunság NP | 8,822 | 271 | 35 |
| Bátorliget NR 1980s | 5,097 | 151 | 28 |
| Bükk NP | 8,464 | 247 | 7 |

The advantage of a search-type inventory is that it results in the most complete species list. Although inventories of the studied Hungarian reserves are still incomplete, the number of recorded species is very high. Any sampling protocol has limitations, which may result in the exclusion of specialist and rare species. For example, during a structured inventory in the Neotropics, where replicated samples were stratified according to method, habitat, and time, 253 ant species were captured. However, a taxonomic specialist registered 202 more species in the same area (Longino and Colwell 1997). Expertise level seems to be the key factor that influences inventory completeness, especially if financial and time resources are limited. Hammond (1994) reflected a similar view, suggesting that if data are not for comparable quantitative samples, educated guesses have the most important role in describing species occurrences.

Search-based biological inventories and ecologically designed inventories differ in an important way. Search inventories provide taxonomic completeness. This may be a primary goal of a landowner or manager, primarily if a limited amount of time and money are available for the inventory. Ecologically designed inventories provide much shorter species lists (Longino and Colwell 1997), but these lists may be comparable to other, similarly obtained lists. Ideally, both methods should be employed at biological reserves in the future.

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*András Báldi is an ecologist who studies the patterns and generating mechanisms of animal distribution in habitat fragments and across habitat edges. He is also interested in the potential of reserve archipelagos to conserve biodiversity in Hungary.*

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