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THREE DECADES OF ZOOLOGICAL SURVEY IN NATIONAL PARKS IN HUNGARY (1974–2002)

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Three decades of zoological survey of the national parks of Hungary is described in a historic context and some of the effects and uses mentioned, especially for Heteroptera. Meta-analysis of published faunistic data allows new conclusions on the species richness and species-area relationships. The diversity indication value of species and higher taxa lists in case of Heteroptera is calculated. The unique research series also allows an overview on the composition and changes of the specialist assemblages, and its effects on the species richness. An evaluation of the survey from nature conservation point is given.

This paper also celebrates the 70th birthday of Dr. SÁNDOR MAHUNKA, acknowledging his extensive assistance to zoology in Hungary, and his central role in the presented research. He is the last editor in chief of the series Fauna Hungariae, was secretary of SIEEC (Symposium Internationalis Entomologica Europae Centralis), was the organiser of the faunistic explorations in the national parks from the very beginnings on. Dr. Mahunka was editor (and co-author) of all the published volumes – and has been a constant good friend and valued colleague.

INTRODUCTION

250 years after LINNAEUS we still know only a minority of animal species living on the Earth. Even less is known about the actual distribution of species, especially in the case of rare species and in the less explored regions. Europe, for historical and traditional reasons, has been much better studied than other continents, and the native species here have become mostly known, together with their occurrence in the fauna of the different countries (often occasionally changing political, and not natural entities). We have, however, data on the fauna of well defined areas only in sporadic cases except for those "faunas" established on the basis of a few, favoured Phyla (Vertebrata, Mollusca, Arthropoda). But here too, "birds and butterflies" are much more preferred than other, often difficult to identify taxa. Inventories of biodiversity covering all taxa are exceptionally rare (BÁLDI 1999, and references therein, KIM & BYRNE 2006).

In this respect the three decade long zoological and botanical exploration of Hungarian national parks is a unique undertaking, though a Swedish species inventory has been started recently (RONQUIST & GÄRDENFORS 2003). The essential goal was to provide extensive data about both flora and fauna of these territories, to learn about what is protected here, and to provide basic information for protection measures and tools. This paper describes the circumstances that made this work possible and, on the basis of data on true bugs (Heteroptera), provides information to generate and support further use of these accumulated, important data sets.

A SHORT HISTORY OF HUNGARIAN ZOOLOGY, LEADING TO THIS RESEARCH

The ability to carry out such an extensive work was based on the development of zoology in this part of Europe. In this respect Hungary, located in Central Europe, was in a unique situation. The pioneer checklist of the fauna of the Hungarian Kingdom (PASZLAVSZKY 1898–1918) was published to commemorate the Millennium of the Hungarian settlement in the Carpathian Basin (1896), and has been feeding ambitions of zoologists of the country ever since.

Between the two World Wars ENDRE DUDITS (1895–1971) and his "school" brought new energy and set comprehensive goals for Hungarian zoology. Their idea, to explore the entire animal world of a small, well preserved area the Bátorliget Nature Reserve (SZÉKESSY 1953), was a great success and brought a surprising result – 4672 species were found in the 20 ha area by 24 collectors and 34 specialists in practically 2 years of field work.

The realisation, that there was no specialist expertise for various animal groups in Hungary, which hindered even the simple identification of much of the material, lead to the launching of the series Fauna Hungariae. The volumes, prepared by an outstanding group of recognised Hungarian and foreign specialists, contain identification keys, short description of the taxa, life histories of species, together with the necessary drawings by excellent illustrators. The 175 volumes published to date cover well over 60% of the known fauna of the country (MAHUNKA 1983). The eco-political changes brought the series to a stop in the 1990s.

In the seventies a new generation of zoologists left the universities, while members of the DUDICH-school were entering higher academic and institutional positions. At this time Hungary – and notably the eminent entomologist and museum director ZOLTÁN KASZAB – played a leading role in establishing and supporting SIEEC. At such meetings entomologists from both sides of the Iron Curtain could gather to discuss and share ideas and establish working relationships.

All these prerequisites were necessary to start the ambitious programme, the all-taxa exploration of the (flora and) fauna of the Hungarian national parks.

THE SURVEY OF THE HUNGARIAN NATIONAL PARKS

A new era has arrived in nature conservation in Hungary, with national parks established to preserve landscapes and traditional cultures as well as "biologically valuable" areas. Reserves were often identified primarily on the basis of their vascular plant flora and bird fauna.

The first, the Hortobágy National Park was founded in 1973. Detailed scientific investigation started, however, in 1974 only, under the organisation of the Hungarian Natural History Museum (HNHM) and with the support of Hungarian Academy of Sciences. The tasks of the survey were set as follows (KASZAB & MAHUNKA 1981):

1. To establish the species composition of plants and animals (nature gene banks) of the territory under investigation.

2. To study the quantitative and cenological conditions … of the fauna living there.

3. To study the autecology, ethology and phenology of the species living there.

4. To explore the very rare species and ecosystems needing protection, and to propose protective measures.

5. To publish the results gained through the scientific investigations in series of books entitled the "*Natural History of the National Parks of Hungary*".

For many scientists the goal was simply to collect, as extensively as possible, specimens and species from the most of the locations and habitats.

After 3 years of field work, collection, preservation and preparation, the material was sent to Hungarian and foreign professionals and qualified amateur specialists, under the leadership of ZOLTÁN KASZAB (1915–1986), then general director of HNHM. Guidelines for the publication of the species, data on their actual and earlier localities, and other data about phenology, biotope, etc., were prepared by SÁNDOR MAHUNKA, than head of the Department of Zoology of HNHM. The efforts resulted in 6860 identified and published animal species, the majority of which were earlier unknown from the territory of the national park.

Then, on the basis of experiences gained from the first research period, a further 4 years collecting started in 1977 in Kiskunság National Park, while the identification and publication of the material from the first area was in progress. Similar explorations were made in the newly established national parks and, as a unique undertaking, the Bátorliget explorations were repeated after 40 years, on the extended area of the nature reserve (MAHUNKA 1991). The results of the individual NP collecting programmes have been published in subsequent volumes of the series: The fauna and flora of the National Parks of Hungary (MAHUNKA 1981, 1983, 1986, 1987, 1993, 1996, 1999, 2002*a*).

ON COLLECTING THE MATERIAL

It is worth noting survey methodologies, since the established species richness of a legally defined area like a national park depends not just upon biogeographic and historic conditions (the area, the diversity of biotopes, land use, etc and the consequent composition and diversity of animal taxa), but also upon the collecting intensity, on the number, expertise and efforts of collector persons, on the methods used, on the goals of the collecting team and finally on the range and richness of taxa identified by the specialists.

The extensive material was collected by (professional and amateur) expert zoologists and non-expert collectors (for some volumes up to 70 such persons, among them many museum preparators are acknowledged for their contribution). It may be assumed, that the majority of species, especially those species difficult to capture, were collected by the specialist experts, while the high number and professional diversity of collectors gave better coverage over the territories and the biotopes, over collecting methods, over the collecting seasons (reaching sometimes into the traditional non-collecting periods for different taxa), and thus resulted in further, even unexpected species as well as in further localities and collecting dates. Both human factors, the collectors and the specialists' assemblage would affect the resulting number of species. Collectors and authors (specialists) changed considerably during the 3 decades of surveys, although the goal to detect the highest number of species from the highest number of localities remained constant. We must compare the faunistic lists with these limitations in mind. Since, however, no such data-set exists in the history of biology, it is worthy of analysis.

METHODS

Supporting information given in the *Contents*, *Introduction* and the *Heteroptera* chapters of subsequent volumes (MAHUNKA 1981, 1983, 1986, 1987, 1993, 1996, 1999, 2002*a*.) and data of SZÉKESSY (1953) and MAHUNKA (1991) was used to rearrange and analyse the published data. As authors those persons were taken into consideration, who were mentioned in the Contents of the volumes and contributed to the quantity of faunistic information. Specialists acknowledged for their contribution in the individual papers were not considered as authors, though unquestionably influenced the number of species reported. To characterise the changes in specialist assemblages from NP to NP, a simple Sørensen index (S=2c/a+b, where a= number of specialist in assemblage 1, b= number of specialist in assemblage 2, c= number of specialists common in both assemblage) was used.

To gain better insight into the fauna and allow further comparisons, species lists in the case of three heteropteran taxa, Nepomorpha, Gerromorpha and Tingidae, were analysed. In the case of these taxa, except for Bátorliget I (SZÉKESSY 1953), the author was among the collectors and specialists, which allowed a deeper understanding of differences in the faunistic lists. Varieties and forms, mentioned in Bátorliget I, were considered to represent the nominal taxon, except when later revisions supported their species rank. A further extensive faunistic work, the comparable list of Heteroptera from the Őrség landscape conservation area by KONDOROSY and HARMAT (1997) was also used during the analysis. Variables in the higher taxa surrogation analysis were log10 transformed to normalise their distribution (BÁLDI, 2003).

Correlation of family, genus and species diversity as well as species-area curves were calculated by the STATISTICA software (StatSoft Inc. 1998).

RESULTS AND DISCUSSIONS

The very high species numbers (Table 1) and the voluminous invertebrate data set itself were surprising to both zoologists and the nature conservation authorities. The simple species lists provided information about the fauna of the administrative territories (mentioned in the form of settlement or geographical locality names), and not or occasionally about either the closer habitat, or the abundance or any other characteristics of the populations of species. This way the published data are of limited use for studying site-specific biodiversity. The species lists could, however, be used to quantify the species level diversity of the Hungarian fauna (BÁLDI 1999).

Concerning Heteroptera, and intensity of their research, 15 species new to the fauna of Hungary were found during this study. This represents 1.8% of the fauna (KONDOROSY 1999, 2005), which is well known from the work of GÉZA HORVÁTH, the eminent hemipterist, before the 2nd World War. During the study, in the investigated 3 heteropteran taxa 28 Nepomorpha species (84.8%), 18 Gerromorpha species (85.7%) and 49 tingid species (75.4% of the known fauna) were recorded from Hungary again. The ratio of published heteropteran species varied between 2.0 and 5.1% of the total fauna of the individual NPs, (in the average of 6 surveys 3.3%) while true bugs are assumed to represent 2.3–2.5% of the species number of Hungary, considering those taxa which were included in the NP surveys (BÁLDI 1999). The area of the mentioned NPs and NR cover altogether 1.8% of the country, which supports the right selection criteria for protected areas as far as heteropterans are concerned.

Field work was often carried out not just on NP areas, but on neighbouring (unprotected) areas as well, where there was enough evidence from previous (primarily botanical) investigations to suggest areas of interest. In some cases the result has led to the establishment of newly protected areas (MAHUNKA 2002*b*). Concerning Heteroptera, results of the Bátorliget II survey (MAHUNKA 1991) (composition and phenology of the terrestrial, forest and grassland true bug fauna) provided the basis for recommendations on land use technology (VÁSÁRHELYI unpublished).

Table 1. Some relevant characteristics of surveyed Hungarian national parks (NP) and the Bátorliget Nature Reserve (NR) (partly from MAHUNKA 2002)

Name of territory	Area (ha)	Main biotopes	Time of collecting	Duration of coll.	Duration of publ.	Total number of species	No of authors
Hortobágy NP	43550	Lowland: dry heath (puszta), alkaline meadows, marshes, canals, open woodlands, pastures	1974–1976	3	7	6860	81
Kiskunság NP	39938	Lowland: dry heath (puszta), alkaline meadows, marshes, canals, lakes, open woodlands, planted pine forests, pastures, sand dunes	1977–1980	4	7	8175	64
Bükk NP	38775	Mountain (200–800 m a.s.l.): deciduous forests, clearings, pastures, streams, artificial ponds	1981–1985	5	11	9436	81
Aggtelek NP	19762	Mountain (200–600 m a.s.l.): deciduous forests, clearings, pastures, streams, artificial ponds,	1987–1991	5	8	7394	57
Bátorliget NR (1953)	20	Lowland: forest, clearings, stream, canal, pond, peat-bog	1948–1950	3	3	4370	24
Bátorliget NR (1991)	374	Lowland: forest, clearings, pasture, stream, canal, peat-bog	1988–1990	3	1	5450	65
Fertő-Hanság NP	23587	Lowland: marshes, channels, lakes and ponds, peat-bog, forest, pastures, meadows	1996-2001	6	1	6508	83

KASZAB and MAHUNKA (1981) set one of the goals as "to study the quantitative and cenological conditions". Very few ecological and cenological results have been published, especially in the case of invertebrate taxa (e.g. VARGA 2002); reasons for this are given by MAHUNKA (1983, 2002*b*). Some results, however, were published outside these volumes (e.g. PAPP & VÁSÁRHELYI 1994, 19 years after the field work). Concerning Heteroptera, BAKONYI (1983) published cenological investigations on the aquatic bug fauna of Hortobágy NP. His habitat characterisation led later to the establishment of "indication value" for the aquatic and semiaquatic Heteroptera species of Hungary (HUFNAGEL *et al.* 1999). The continuous collecting opportunities made it possible to investigate the postembryonal development and life history of several Heteroptera, especially Aradid species. The results are reported in various publications, e.g. VÁSÁRHELYI (1985).

The high numbers of reported animal species were unexpected for zoologists as well as the nature protection authorities. On the basis of the published data positive correlation between the area and the species richness could be detected for the total fauna (Fig 1, $p = 0.027$). The correlation was not significant for true bugs (Fig 2, $p = 0.154$), but the trend seems to be present. The number of investigated units (6) is in fact too low to draw definite conclusions in this respect. Furthermore, species richness without respect to the faunistic (species) composition or other features e.g. number or ratio of generalist/specialist species is not a sound indicator for the conservation value of an area; different species have different roles in the ecosystems and react differently to natural or anthropogene changes (see e.g. LÖVEI *et al.* 2006).

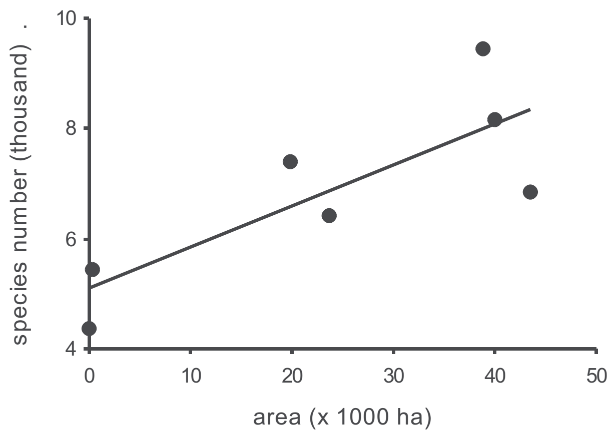

Fig 1. Species' number as a function of the area of Hungarian National Parks and Bátorliget Nature Reserve ($y = 0.0748x + 5.0967$, $R^2 = 0.658$)

BÁLDI (2003) used data published on the Coleoptera, Diptera and Acari species of the Kiskunság National Park, to test whether higher taxa (genus and family) were good surrogates of species richness in these larger groups (2415, 1004 and 288 published species, respectively). His positive results came from an assemblage of 16 different areas of this NP, studied between 1977 and 1981 and the material identified by the same experts.

A similar calculation was now made on the basis of the Heteroptera data of all different areas and explorations, collected between 1974 and 2001 and identified by heteropterists, to test if differences in the ratio found on other animal groups was true for Heteroptera, when all the circumstances described above were affecting the taxonomic composition of "a fauna". There is a strong correlation between the genus and species numbers (Fig 3, $p = 0.000$), whereas the correlation between family and species numbers is not significant ($p = 0.071$). In the case of Heteroptera, intensity of expert sampling (manifested in collecting days and efforts by specialists) yielded greater diversity (11.8, 11.1 and 10.1 species/family, respectively) compared to the other surveys, when the majority of material was collected by non-heteropterist colleagues (5.3–7.8 species/family). The results, from biogeographically distinct areas, do not counter the general opinion (c.f. BÁLDI 2003, SÁNCHEZ-FERNÁNDEZ *et al.* 2006), that family level surveys may indicate species diversity of certain areas, but neither the actual richness, nor the species composition can be directly inferred from these data (in itself this may further emphasise the importance of the role of specialists in biodiversity research). These volumes about data-rich regions may, furthermore, serve as a basis for investigations to examine the potential effectiveness of surrogate approaches, as suggested

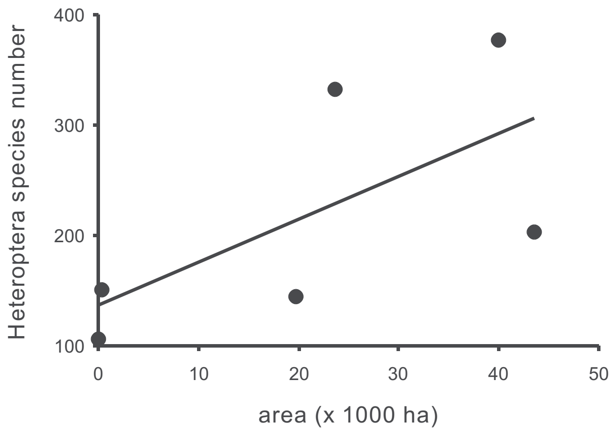

Fig 2. Heteroptera species numbers as a function of the area of Hungarian National Parks and Bátorliget Nature Reserve ($y = 3.8999x + 136.3$, $R^2 = 0.435$)

by FAVREAU *et al.* (2006), or the distributional similarity (congruence) between phylogenetically independent taxonomic groups (PAWAR *et al.* 2007).

This voluminous work has been carried out in the last 2 decades of political separation of Europe, and in the first decade of the democratic and market economy era for Hungary. To analyse this unparalleled co-operation of European experts the author lists were compared using simple Sørensen index (Table 2). The 5 decade long exploration (1953–2002) involved 209 authors. Three zoologists took part in all surveys, thus, even with such a long time period, 5.6% of similarity could be detected. The similarities in the more recent surveys (last 3 decades) fall between 66.2 (Hortobágy–Kiskunság) and 24.39 (Hortobágy–Fertő-Hanság).

Similarities between two subsequent surveys are, as expected, larger than between surveys further separated in time. There seems to be, however, a further "erosion" of author assemblages during the 3 decade period, since similarities between pairs of subsequent surveys decrease, from 66.2 to 48.2. The reason for this may be the ageing of the members of the "DUDITS School", the departure of ZOLTÁN KASZAB, well known for his talent for co-operating with fellows worldwide, and in some cases in the burning out of scholars participating.

The extensive exploration could not be completed by the museum staff only, though they represented half (19 out of 37) of the most prolific authors (4 or more NPs). Only 27.3 % of the authors (57) were working for the HNHM at some time.

Foreign authors (42) represented 20.2% of the total list and their participation was uneven. In the first 3 surveys on average 16.0 foreign authors contributed to the volumes, whilst only 8.3 contributed to the last 3 surveys. This might partly be due to the death of ZOLTÁN KASZAB in 1986 – the 6 colleagues who ended their continuous contribution after the third survey (Bükk NP) were his fellow Coleoptera specialists. Other foreign colleagues contributed to 1–2 surveys only during the 3 decades.

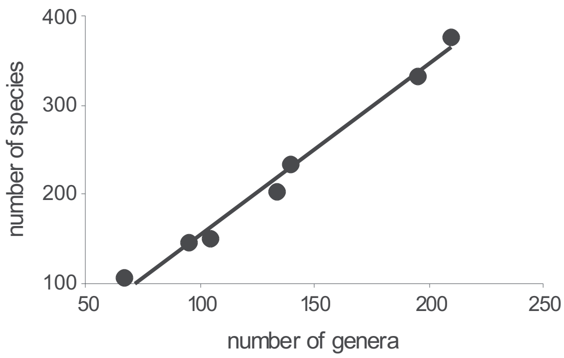

Fig. 3. Correlation between Heteroptera genus and species' numbers of Hungarian National Parks, the Bátorliget Nature Reserve and the Őrség LPA ($y = 1.9177x - 38.027$, $R^2 = 0.986$)

Table 2. Similarity (expressed in Sørensen index, given in %) of the author assemblages of the surveyed Hungarian National Parks and Bátorliget Nature Reserve

	Bátorliget NR I	Hortobágy NP	Kiskunság NP	Bükk NP	Bátorliget NR II	Aggtelek NP	Fertő-Hanság NP
Bátorliget I	–	19.0	18.2	9.5	11.2	4.9	5.6
Hortobágy NP		–	66.2	51.9	39.7	36.2	24.4
Kiskunság NP			–	59.3	41.9	39.8	27.2
Bükk NP				–	57.5	53.6	39.0
Bátorliget NR II					–	49.2	40.5
Aggtelek NP						–	48.2
Fertő-Hanság NP							–

We have shown that collecting intensity and expertise influence the number of species in a survey. The specialist knowledge (the size of taxonomic units covered by individuals) of the co-operating taxonomists obviously influence the taxonomical coverage of the team and the higher number of taxonomists working on different animal groups is expected to increase the number of species identified from the collected material. No significant correlation ($p = 0.139$) was, however, found between the number of authors (specialists) and number of species (Fig. 4). This overview underlines the importance of 1) maintaining diverse specialist teams, who can serve as core-group at such large scale surveys, and 2) developing broad networks of allied specialists, who fill the gaps in collecting expertise and taxonomic coverage.

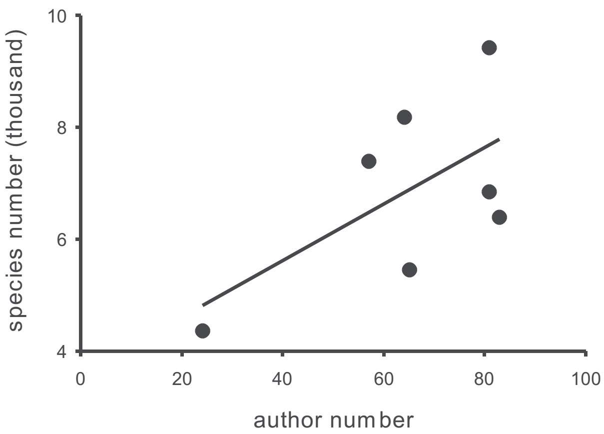

Fig. 4. Species' numbers as a function of the number of specialists (authors) involved in preparing the publication of the fauna of Hungarian National Parks and Bátorliget Nature Reserve ($y = 0.0502x + 3.6083$, $R^2 = 0.3816$)

These decades had their impact on the training of zoologists, too. At the start of the work the collectors mainly used the only car of the HNHM and emphasis was put on efficient use of the car through one-week sampling periods conducted jointly by diverse, expert and non expert working companions. This gave participants the opportunity, besides exchange of ideas, to listen to, learn and experience various collecting methods, for various animal taxa, as utilised by a diverse set of personalities, foreign and Hungarian zoologists. The slow changes in the staff over the decades made it possible to develop and maintain a certain working culture, respect for each others' interests, and donation of time and effort to capture or collect for each other. These sharing and learning opportunities had a beneficial effect on the development of a generation of enthusiastic Hungarian zoologists, who now carry out field work and taxonomic studies in other parts of the world, e.g. the Palaearctic and Oriental (e.g. RONKAY 2005, PAPP L. 2005, PAPP J. 2007), the Ethiopian (e.g. SZŰTS & SCHARFF 2005, CSUZDI 2006, MAHUNKA & MAHUNKA-PAPP 2007), or the Neotropic (e.g. MAHUNKA 2006, BÁLINT & WOJTUSIAK 2006) regions. As KIM and BYRNE (2006) poined out: "At present there are very few professional taxonomists and trained local parataxonomists worldwide, while the need for, and demands on, taxonomic services by conservation and resource management communities are rapidly increasing". The possibility of the surveys in itself was a great help in training zoologists who were able to identify the vast majority of species collected from an area.

CONCLUSIONS

Looking back to the 5 decades of faunistical surveys made on Hungarian national parks and nature conservation areas, we introduced shortly the history of this endeavour, and analysed from various points the work and the published results, too. The sporadic cross-voluminal analyses show to weak as well as strong points of the results, and suggest that the entire data set is able to support various analyses towards further faunistic, cenological, and conservation research. The accumulated data could further be used for national parks management and development if the results were presented in the form or context relevant for the authorities.

All taxa or single taxon faunistic lists from individual localities or habitats within the large unit of a national park may easily be computed. When necessary, such lists could be completed using the information given on the museum specimens (preserved in the Hungarian Natural History Museum), or even the collecting information from the records of the collectors. Such data set could serve as taxonomical basis for ecological studies, even when the focus of research is on a smaller taxon or a species, and could support decision making about advanced conservation measures planned with attention to more than the traditionally preferred species. Besides, species composition may indicate undisturbance of ecological processes. Comparison of the recorded fauna with results of present or future surveys may indicate the quality of scientific data based nature protection measures over longer periods of time. On the other side, such investigations may be useful in studying the indicator value of certain organisms or establishing long-term monitoring programs. This survey of the past decades, according to the intentions of its organisers, provides an extensive basis for new, future efforts of Hungarian zoology.

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