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Current Efforts to Monitor and Conserve the Eastern Imperial Eagle *Aquila heliaca* in Hungary

The globally threatened Eastern Imperial Eagle *Aquila heliaca* has been one of the flagship species of Hungarian bird conservation efforts since the 1980s. Due to these conservation activities and positive land-use changes during the last 2 decades, the Hungarian Imperial Eagle population increased from as few as approximately 20 pairs in the early 1980s to 81 pairs by 2006. Between 2002 and 2005 as part of a LIFE-Nature project, MME/Birdlife Hungary carried out particularly intensive monitoring, conservation, research, and public awareness actions. The main goal of the project was to secure the long-term sustainable increase in the Imperial Eagle population after Hungary's European Union accession in 2004. New methods were developed and applied to census and monitor the breeding and wintering population sizes. Standardized baseline land-use mapping and surveys were introduced to detect long-term land-use and prey density changes in priority areas for Imperial Eagles and to monitor the effects of key mortality factors, such as electrocution. Historical information and data gathered before and during the project period were assimilated using a Geographic Information System and incorporated into a comprehensive set of Imperial Eagle Management Guidelines.

INTRODUCTION

The Imperial Eagle is a top predator of the Eurasian wooded steppe region. Despite its large area of distribution, it is a globally threatened species, classified as Vulnerable (1).

The Hungarian Imperial Eagle population has gradually increased since the late 1970s and early 1980s (2, 3) becoming the most important source population in Central Europe. However, Imperial Eagle habitats are constantly changing, and this process was significantly accelerated by the accession of Hungary to the European Union in 2004. Recently introduced policies and assistance schemes may profoundly influence the structure of agriculture. Their long-term effects on bird populations associated with these fairly intensively used habitat types are currently unpredictable.

Between 2002 and 2005, the LIFE-Nature project (4) "The conservation of *Aquila heliaca* in the Carpathian Basin" funded mapping and surveys on Imperial Eagle territories in Hungary to set a baseline against which to monitor long-term changes. The aim of the data collection was to describe the land-use composition of foraging areas, key prey species' densities, and the distribution of the main mortality factors before accession to the European Union.

MATERIALS AND METHODS

Monitoring of the Breeding Population and the Number of Nonterritorial Individuals

In 2002 MME established an extended Imperial Eagle monitoring network with more than 70 participants country-wide. The core project team developed standardized recording forms and instructions to support the field work and reporting process of the observers. Breeding pairs were located in the beginning of each breeding season and were checked regularly to verify their presence.

Eastern Imperial Eagle *Aquila heliaca* (Photo: A. Kovács).

It was proved during the project that nonterritorial, mostly juvenile and immature eagles congregate in winter in temporary settlement areas, supposedly due to high winter prey density. Temporary settlement areas were identified using a complex data analysis of approximately 7000 field observations (Horváth et al., unpubl. data), 1800 satellite tracking records (Kovács et al., unpubl. data), and 460 VHF tracking records (Demeter et al., unpubl. data).

Monitoring of Land Use and Prey Density

Between 2003 and 2005 a total of 551 km^2 was mapped to collect information on land-use composition and prey densities on 3 territories in a 5-km radius around nest trees. Land-use mapping was carried out in the field using 1 : 10 000 topographic maps, Global Positioning System equipment, and a Corine Land Cover (Coordination of Information on the Environment) (5)

Table 1. Land-use composition on 3 sample territories (T1, T2, T3) within a buffer of 5 km around nest trees between 2003 and 2005.

Land-use type	T1	T2	T3	Mean proportion of land-use types
Winter wheat	35.39%	25.81%	15.65%	25.62%
Sunflower	19.36%	15.47%	5.91%	13.58%
Natural grassland	11.69%	26.31%	21.20%	19.73%
Natural forests and tree plantations	6.42%	2.01%	8.73%	5.72%
Corn	5.44%	11.59%	0.86%	5.96%
Spring barley	5.23%	0.00%	0.00%	1.74%
Fallow land	4.02%	1.10%	2.11%	2.41%
Alfalfa	2.94%	3.35%	0.44%	2.24%
Other crops	2.68%	3.34%	4.62%	3.55%
Squash	2.24%	1.38%	0.11%	1.24%
Rape	2.04%	1.80%	4.44%	2.76%
Water bodies	0.61%	0.27%	0.93%	0.60%
Wetlands	0.46%	1.72%	0.58%	0.92%
Winter barley	0.43%	1.68%	1.53%	1.22%
Permanent crop	0.43%	0.62%	14.36%	5.14%
Heterogeneous agricultural areas	0.36%	0.01%	0.49%	0.29%
Wasteland	0.22%	1.54%	5.23%	2.33%
Artificial surfaces	0.05%	1.84%	5.04%	2.31%
Arable land	0.00%	0.00%	0.00%	0.00%
Pastures	0.00%	0.03%	0.00%	0.01%
Transitional woodland/shrub	0.00%	0.13%	7.76%	2.63%
Total	100.00%	100.00%	100.00%	100.00%

classification specifically developed for fine-scale land-use and vegetation mapping at landscape level (6). Mapped data were digitized and analyzed by a Geographic Information System.

As key prey species for the Imperial Eagle (7), the density of the European Brown Hare *Lepus europaeus* and the Pheasant *Phasianus colchicus* was surveyed using a line transect method (8) on the 3 territories between 2003 and 2005. The presence and density of the European Ground Squirrel (Suslik) *Spermophilus citellus* and Hamster *Cricetus cricetus* were estimated through occupied burrow counts.

Monitoring the Effects of Electrocution as One of the Key Mortality Factors

According to present knowledge, the key human-related mortality factors of the Imperial Eagle are electrocution, poisoning, and collision with vehicles (7). Young birds in their first 2 y are thought to be the most vulnerable age group, forming 70% of the total of Imperial Eagle specimens recovered dead.

Before 2003, medium-voltage electric poles were sporadically visited to estimate the effect of electrocution on threatened bird populations in Hungary (9). To gather standardized and representative data about bird electrocution, nationwide surveys were conducted with the voluntary participation of 132 MME members in November 2004, April 2005, and September 2005 (10). Volunteers used a standard reporting form with explanatory guidelines.

RESULTS

In 2005 the Hungarian Imperial Eagle population consisted of 79 known territorial pairs (7). Partly due to the extended monitoring activity, 19 new nesting Imperial Eagle pairs were found between 2003 and 2005, representing a 35% nominal population increase. All new pairs occupied lowland territories in predominantly agricultural areas.

During the project, a total of 22 temporary settlement areas were identified, of which 6 areas were considered to be of high importance because the number of eagles exceeded 5 (7).

Table 1 presents the proportion of different land-use types mapped on 3 territories between 2003 and 2005. The proportion of land-use types differed greatly between sample territories. An average 62.6% of the mapped area was arable land, 20.6% was covered by open seminatural land-use types (grassland and marshland), and only 5.7% was identified as natural forest or tree plantations.

The European Brown Hare and Pheasant population density varied greatly between 5.7 and 21.6 individuals ha^{-1} in the 3 sample areas between 2003 and 2005, reflecting the differences in land-use composition between lowland and foothill territories.

The European Ground Squirrel was present on only 7% to 14% of the surveyed grassland sites in 2003 and 2004. The average density was 20 to 24 individuals ha^{-1} on inhabited grassland mosaics. The Hamster surveys showed extremely low levels of presence and population densities. Only 5% to 20% of the sampled crop fields contained 0.25 to 0.5 occupied burrows ha^{-1}.

In the period between November 2004 and September 2005, approximately 6500 medium-voltage electric poles were visited by 132 participants during national surveys on bird electrocution. This represents only approximately 1% of the total number of medium-voltage electric poles in Hungary. The survey aimed at assessing the effect of electrocution on the Imperial Eagle's and other threatened birds' populations. Eight hundred seventy-seven electrocuted bird specimens of 46 different species were found, including 7 juvenile Imperial Eagles. An additional juvenile Imperial Eagle survived the electric shock and was rehabilitated and released successfully. The 8 electrocuted Imperial Eagles represented the 20.6% of all specimens found dead or injured during the project period. As main targets for future modifications and insulation activities, nearly 2300 km of medium voltage electric lines were mapped during the project in 5-km buffers around known nest sites.

The gathered information, together with historical and recent data on population size and breeding success in the past 25 years, was processed in a Geographic Information System forming a part of the most complete single-species system in Hungary to date.

DISCUSSION

The Imperial Eagle hunts predominantly in open areas that are managed by different agricultural schemes in Hungary. One of the main tasks regarding the conservation of the Imperial Eagle is to provide detailed information for policy makers and farmers on agricultural management schemes through which the remaining populations of key prey species can be increased or at least stabilized at landscape level.

The results of the land-use mapping and the surveys on prey density between 2002 and 2005 helped to develop key concepts on eagle-friendly management methods for open foraging areas, providing a basis for more effective future foraging habitat conservation (11). During the project, relatively permanent landscape elements, such as grasslands, grassy field margins, and bushy tree lines among agricultural fields, were identified as priorities for key prey species. The area increase in alfalfa, winter cereals, wasteland, fallow land, winter fodder, and winter-sown pastures can also be beneficial. Other important crop types to be maintained are corn (silage maize), spring cereals, crops cultivated at a smaller scale (e.g., sorghum, millet, canary seed, foxtail millet, pea, soybean, oil pumpkin, mustard, winter and spring fodder mixes), and spring rape.

Besides habitat conservation and development, the effects of key human-related mortality factors, such as electrocution, should be reduced in priority Imperial Eagle areas. Although modification of the most dangerous power lines has been under way in Hungary since the 1980s, the slow pace of this activity could be accelerated with more support from electricity companies. A new legislative tool is also necessary to ensure that new power lines are built with bird-friendly structures.

Based on monitoring activities between 2003 and 2005, recommendations regarding the maintenance of habitat suitability and population viability were incorporated in the Imperial Eagle Management Guidelines and disseminated to key stakeholders in 2005 (12). The document provides as background material a summary of the most recent information on the biology of the Imperial Eagle and based on this recommends actions for developing nature conservation policy, providing law enforcement, maintaining habitat suitability, reducing individual mortality of eagles, and increasing public awareness about eagle conservation opportunities.

References and Notes

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13. More than 70 people take part in the monitoring of the Imperial Eagle population in Hungary each year, including volunteers and national park staff. In addition, approximately 60 volunteers participated in the national surveys of electrocuted birds between 2004 and 2005. We thank these individuals for their hard and enthusiastic work on data collection. The prey species surveys were carried out by Péter Borbáth, Attila Ferencz, József Kelemen, Károly Kovács, Mihály Molnár, István Németh, and László Tóth. We are particularly grateful to Paola Movalli Duke for organizing the Scopello workshop and facilitating the publication of this Special Issue. We thank Chris Wernham, Jan Ove Gjershaug, and Torgeir Nygard for their useful advice on the manuscript. The LIFE-Nature Project "Conservation of the Imperial Eagle in the Carpathian Basin" was cofinanced by the European Commission's LIFE-Nature Fund and the Ministry of Environment and Water in Hungary.

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