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Breeding and migration of the Black Stork (*Ciconia nigra*), with special regard to a Central European population and the impact of hydro-meteorological factors and wetland status

Doctoral (PhD) thesis

Tamás Enikő Anna

Supervisor: Dr. Szép Tibor

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Ezen értekezést a Debreceni Egyetem Juhász-Nagy Pál Doktori Iskola Biodiverzitás Doktori Programjának keretében készítettem 2010-2011-ben, és ezennel benyújtom a Debreceni Egyetem természettudományi doktori (PhD) fokozatának elnyerése céljából.

Debrecen, 2012. január

Tamás Enikő Anna

Tanúsítom, hogy Tamás Enikő Anna doktorjelölt 2010-2011-ben a fent megnevezett doktori program keretében irányításommal végezte munkáját. Az értekezésben foglalt eredményekhez a jelölt önálló alkotó tevékenységével meghatározóan hozzájárult. Az értekezés elfogadását javasolom.

Debrecen, 2012. január

Dr. Szép Tibor

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Értekezés a doktori (Ph.D.) fokozat megszerzése érdekében, a TERMÉSZETVÉDELMI BIOLÓGIA tudományágban

Írta: TAMÁS ENIKŐ ANNA okleveles ÉPÍTŐMÉRNÖK

Készült a Debreceni Egyetem JUHÁSZ-NAGY PÁL doktori iskolája (BIODIVERZITÁS programja) keretében

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A bírálóbizottság

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tagok:	....	....
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Az értekezés védésének időpontja: ....

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1 Introduction

1.1 Problem definition

People have been altering the Earth's surface for thousands of years (Drower 1954, Cole 1976, Brookes 1988). Land use and cover changes, caused by increasing human habitation coupled with resource consumption and extensive landscape modification, adversely impact natural ecosystems at multiple spatial scales (Faulkner 2004). Habitat loss has induced increased extinction risks for rare and highly specialised species, and particularly to migratory birds (Senra & Alés 1992), as migratory birds and species with specific habitat requirements are considered to be the most sensitive to anthropogenic disturbances (Croonquist & Brooks 1991).

Many publications can be found on the prominent effects of habitat loss on the populations of migratory birds, in their breeding grounds, wintering grounds and along migration routes alike (e.g. Batten et al. 1990, Collar & Stuart 1988, Bibby 1992, Newton 2004, 2006). In order to better understand the real status and conservation needs of these species, detailed knowledge on the breeding ecology, habitat and diet preference, dispersal and migration are needed. A single survey with habitat measurements can be used to predict occurrence according to habitat, but to investigate population processes, reproduction must be studied also as a priority (Bibby 1992). Problems may be diagnosed by studying breeding performance across time (Bibby 1992). In long-lived species, survival is also a key question, so it constitutes a preferential target for conservation measures (Lebreton 1978, Stearns 1992, Schaub et al. 2004). A complete understanding of population dynamics would require, among other factors, the analysis of dispersal (Pradel et al. 1997, Clobert et al. 2001).

In conservation biology, some of the most important challenges are to assess the status and risk factors of migratory species, as well as to foster decision making in habitat management and restoration for optimal conservation actions (Lebreton & Clobert 1991, Caswell 2001). A current trend is that more industrialized countries are likely to conserve their already impacted, remaining habitats, while nations with less industrialization are now experiencing accelerated losses, and may continue to do so for the next several decades (Brinson & Malvárez 2002). Restoration measures have to be planned and implemented before changes reach a point when restoration efforts become too costly or ecologically unattainable (Croonquist & Brooks 1991). By understanding the functional attributes of avian species we can determine what aspects of the habitat are important for effective management and restoration, to reverse the effects of cumulative impacts (Croonquist & Brooks 1991).

The above-mentioned factors certainly have an impact also on the Black Stork (*Ciconia nigra* Linnaeus 1758), though the significance of these effects on the populations of this particular species is not very well known.

1.2 Goals and aims of the study

According to the Sherry-Holmes model for understanding population limitation in migratory birds (Sherry & Holmes 1995), the four major periods when populations may be studied (breeding, wintering, and two migration periods) are distinguished.

This model suggests that migratory bird populations can be limited by conditions on either the breeding or wintering grounds, or by factors that occur while in transit between these. Populations of migratory birds are often considered to be limited in breeding or wintering areas (Newton 2004), but some might be highly influenced also during migration (Newton 2006). Breeding ground limitation can occur in the form of effects on survival rates of breeders or variations in nesting success that change population trajectories, with emphasis on the role of variation in habitat quality on the rates of survival and reproduction (Faaborg et al. 2010).

A characteristic influence can be attributed to stopover sites, e.g. in form of competition for food supplies, as birds can concentrate in places like this in great numbers, and food can become scarce (Newton 2006). Most of nonbreeding-season demographic studies have tended to focus on survival rates, as this is the most obvious demographic factor at this time of year (Faaborg et al. 2010). But conditions at stopover sites can influence, among other factors, refuelling rates and migration speeds, subsequent reproduction and survival, and through these, population trends as well (Newton 2006). Particular aspects of this subject area have been reviewed, among others, by Moore & Simmons (1992), Moore et al. (1995), Drent et al. (2003), as well by Jenni & Schaub (2003).

For the Black Stork in Eurasia, most of the effort of studies during the nonbreeding season was invested in Western Europe and the Western migratory route (Bobek et al. 2004, 2008, Chevallier et al. 2008, 2010a, 2010b, 2011, Jiguet et al. 2011), and this is a great inequality, as the vast majority of the European population is supposed to be Eastern migrant (Tamás, Kalocsa et al. 2006).

In my work, I try to summarize present knowledge on an Eastern migrant European population of the Black Stork, and investigate some of the factors for the breeding season and during migration. The biggest threats to the Black Stork are considered to be the decrease in availability and quality of nesting trees and feeding grounds, especially the various streams and water bodies of all kind in the entire range of the species (Tamás, Kalocsa et al. 2006). I would like to outline the dependence of the Black Stork during its breeding season and autumn migration on the status and availability of floodplains and other types of temporary wetlands along the flyway, in terms of reproductive success, and the timing and success of migration. I would like to stress the importance of some extraordinary wetlands along the Black Stork flyway, discover the threats affecting these, and give a suggestion on the substantiation of a Black Stork-friendly forest and wetland conservation strategy.

I would like to summarize the achievements of the fieldwork and studies in which I actively participated in the past 15 years, in relation to the breeding ecology, habitat preference, diet and feeding places, longevity and survival, dispersal and migration of the species.

1.3 Studied species

1.3.1 Field characters

The Black Stork is a large wading bird in the family Ciconiidae; Genus: Ciconia (Brisson 1760). The Black Stork is a large bird, nearly 1 m tall with a 140-180 cm wingspan. The Black Stork is a shy and wary species, unlike the closely related White Stork (*Ciconia ciconia* L. 1758). The plumage of adult Black Storks is all black except for the white belly and axillaries. Bare parts are fire red. The plumage of pulli is all-white, of first-year fledged young is brown, their beak and legs are yellowish. Subadult individuals (2 calendar year, hereinafter: cy) get their shiny black colour gradually, their body coverts and remiges often stay brown in the second summer, while the colour of the legs is brownish red. (Jadoul 1998).

1.3.2 Habitat

The Black Stork inhabits its range insularly, attached to wetlands and suitable nesting grounds (del Hoyo 1992). One of the first descriptions of Black Stork habitats was written in 1893 (Löwis), describing it as nesting remotely from human populations, but near to water bodies, in intact forests, on the branches of large, strong trees or in rocks. However, exact characterisation of the breeding habitat is very scarce in literature[1]. In Central Europe the species is strongly bound to characteristically intact, old, natural or natural-like forests and river valleys: extensive alluvial floodplains represent one of the key habitat types for Black Storks in Central Europe (Sackl & Strazds 1997).

1.3.3 Distribution

The Black Stork is recorded in over 100 countries of the World, in three continents: Europe, Asia and Africa. It is breeding in all these 3 continents (del Hoyo 1992, Janssen et al. 2004). The Black Stork is a breeding species all over temperate Europe, ranges from Russia to France, Spain and Portugal and from the Baltic countries to Greece (del Hoyo 1992). The Black Stork is a unique species from different points of view, out of which extensive breeding range, the biggest one among all species of storks is remarkable (Hancock et al. 1992).

1.3.4 Population

Despite that the population size is estimated at 20-25000 breeding pairs in the world and 7800 to 12000 pairs in Europe (BirdLife International 2004), the species is not considered common in the range countries. The European population is distributed in 35 countries. Distribution and population size in Asia is only partly known: bigger populations inhabit Turkey, China, Mongolia and the area of the former Soviet Union. From other countries of Asia no population estimates are published. African

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[1] Strazds M. PhD thesis University of Latvia 2011.

breeding grounds lie in Zimbabwe, Zambia, South Africa and Kenya. (Janssen et al. 2004).

1.3.5 Movements

The Black Stork is a long-distance migrant, winters in all three continents of range (southern Europe: e.g. Spain; Asia e.g. India and in Africa). The biggest known wintering grounds from Europe lie in sub-saharan Africa, North of the Equator (Janssen et al. 2004). Is a soaring bird, like most raptors. During its migration it avoids crossing seas and mountain ranges. The species uses stopover refuelling sites along migratory routes.

1.3.6 Conservation status

The Black Stork is considered to be threatened in most of its range countries, in 67% of its entire range[2], as is a habitat specialist and not very adapTable to changes in habitat conditions, furthermore it is very sensitive to disturbance. Luthin (1987) categorised the species as globally vulnerable, however, the Black Stork has never been officially listed as such[3]. A major problem lies in the fact that none of the single range countries, neither the most stork-rich nor the most resource rich is responsible for the entire population. Supposedly because the species is rare in all its range countries, shy and very sensitive to disturbance, it is one of (if not) the least known large wading bird species breeding in Europe. In Europe as a whole the Black Stork is classified as Rare (less than 10000 pairs), its conservation status is “Unfavourable” and it is listed as SPEC2 (BirdLife International 2004), stressing Europe’s global

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[2] II. International Conference on the Black Stork, 1996.

[3] Strazds M. PhD thesis, University of Latvia 2011.

responsibility for the welfare of this bird, and underlining the importance of research and the need for the development of habitat management and conservation on the regional and international level as well.

1.3.7 Population and conservation status in Hungary

Overall population surveys of the Black Stork in Hungary are documented from the 20th century. In his work, Homonnay (1943) published the first distribution map of the species in the country. He collected information from foresters and village authorities across the country, and estimated the total population at around 80-100 breeding pairs in Hungary (fig. 1; extending at that time beyond the current borders). According to Homonnay (1943), the breeding area of Black Storks was larger in the past, and decreased together with the decrease of naturally forested area in the Carpathian Basin. Cramp (1977) quotes Bauer & Glutz von Blotzheim (1966) stating the population size in Hungary in the 1940's was around 50-60 nesting pairs, supposedly referring to the (current) territory of Hungary after World War II. The next survey was conducted during the 1970`s, and covered approx. 70% of the territory of the country. It was organized by MME BirdLife Hungary[4] (fig. 1). Haraszthy (1984) also refers to this survey, supplemented by an additional data collection in "Breeding birds of Hungary" (fig. 1).

Since 1995, regular surveys were conducted in 1995, 2000, 2003 with participation of volunteers of MME BirdLife Hungary (fig. 1, Kalocsa & Tamás 1996a, 2004d). In recent years reports are regularly published including the results of repeated population counts (e.g. Kalocsa & Tamás 2004c, 2005, 2007, 2009b, 2010), reporting respectively higher numbers (fig. 2). Summarizing the available population data, the Black Stork population, which was reported to seriously decline all over central- and

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[4] Faunistical Database of MME BirdLife Hungary, ed. Molnár L. unpub.

western-Europe in the first half of the 20th century as the White Stork (Janssen et al. 2004, Bairlein 1991), seems to be increasing in Hungary in the last few decades. However, the increase in volunteer activity cannot be exactly accounted for, thus the net growth in population cannot be assessed reliably (Kalocsa & Tamás 2004c, 2005, 2007, 2009b, 2010).

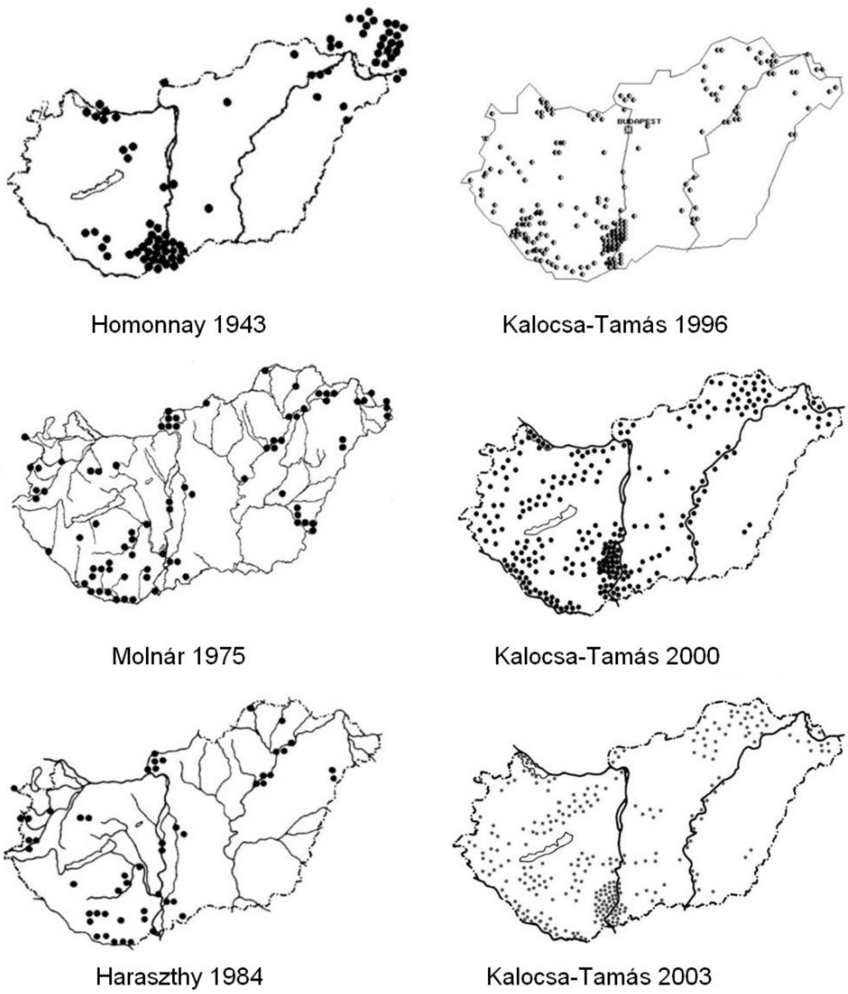

Figure 1 Historical surveys on the Black Stork population in Hungary (author, year of survey)

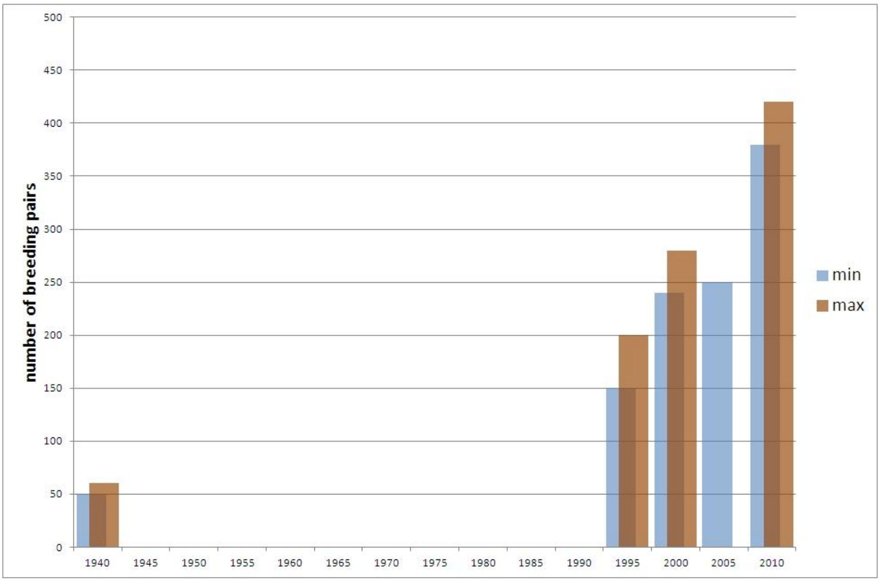

Figure 2 population changes of the Black Stork in Hungary, where min. indicates the number of proven breeding pairs and max. is the number of located territories

The current Hungarian population of the Black Stork represents ~2 % of the World population of the species and ~5 % of the European one. From the maps (fig. 1) it can be clearly seen that the population is concentrated along the three major rivers (Danube, Tisza and Drava), and densest is in the southern part of the Danube valley.

The Black Stork is strictly protected by law in Hungary, and considered a rare but regular breeder.

1.4 Study area

Extensive alluvial floodplains represent one of the key habitat types for Black Storks in Central Europe (Kalocsa & Tamás 1996a, Schneider-Jacoby 1999, Kalocsa & Tamás 2002a). One of the most important and the most near-natural floodplain complex in whole Central Europe lies along the Danube, from the mouth of Sió channel near Szekszárd in Hungary downstream to mouth of the Drava and Dalj in Croatia and Bogojevo in Serbia, covering 75000 ha of alluvial wetlands (Diester 1994), in the floodplains of the Pannonian Central Danube, divided into three by country borders. The Pannonian Central Danube extends from rkm 1500 to rkm 1400 along the Danube. At least 70% of the floodplain's area is covered with alluvial forests, which are dominated by soft-wood Salix alba and Populus alba/nigra forest communities, and hardwood Quercus robur and Fraxinus angustifolia forests. Most of the valuable wetland habitats are already cut-off from the river and native forest communities have been logged (Tucakov et al. 2006). However, there are still important fragments of old forests, as well as numerous river side-branches and marshes. Natural and semi- natural forest stands dominate over the area as well as plantations of allochthonous three species, mainly hybrid fast-growing poplars. This area, the floodplain of the Pannonian Central Danube, continuing downstream beyond the borders of Hungary along the river until the Drava mouth, with an average of 20 bp/100 km^2 is considered to hold the densest known Black Stork population on Earth (Janssen et al. 2004). For the study of breeding habitat selection and diet preference of the species, I chose this, very characteristic area.

Gemenc, Béda and Karapancsa are three smaller regions within these floodplains in Hungary, parts of the Danube-Drava National Park. The northernmost is known as Gemenc, a protected area since 1977, part of the National Park since 1996, Ramsar site, IBA and Natura 2000 area as an SPA. Most of it is still an inundation area, up to 11 km in width, while some territories in Béda and Karapancsa are laying outside the flood protection dams. For breeding success, data collected in the Hungarian part of the Pannonian Central Danube floodplains are used.

For the studies on the diet and characteristic feeding places the study area is the same part of southern Hungary, supplemented with field experiences from Romania and central Turkey. For the determination of survival rates, the study area is Hungary.

Dispersal is studied on European level, while my research focusing on the migration and stopover sites of the species were carried out on the Eastern migratory flyway, across Hungary, Romania, Bulgaria, Turkey, Syria and Israel towards Eastern and Central Africa (fig. 3).

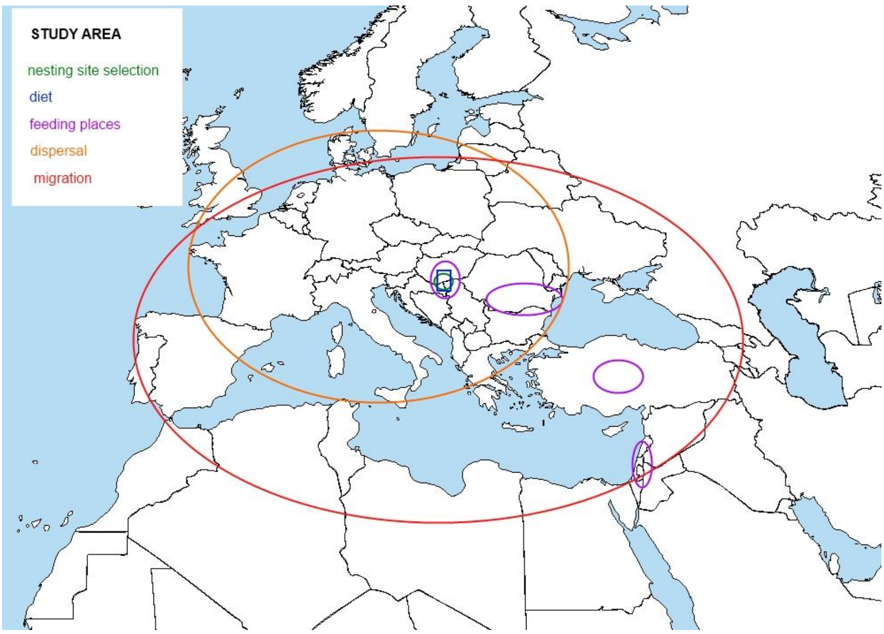

Figure 3. The study area

1.5 Overwiev of the scope of study

1.5.1 Nest site selection

It is known for a long time, that some factors playing key roles in the reproductive success of birds, e.g. food resources and nesting site choice, determine mostly the topographical distribution of a species, but these factors, at the same time, often do not explain fully the mechanisms of habitat selection (Hildén 1965).

Habitat selection is a crucial process in the life cycle of animals because it can affect most components of fitness (Danchin et al. 1998). Different species of plants and animals are found in different habitat types, and they can have different development rates or life spans in the different places (Pulliam & Danielson 1991). As natural and anthropogenic forces as well change the availability of the different types of habitats, the proportion of individuals of a given species in a habitat type can also change. So population size and growth rate may change as functions of the proportion of the different types of habitats (Pulliam & Danielson 1991). For several bird species, it has been already proven long ago, that demographic rates can be habitat specific (Pulliam & Danielson 1991), including e.g. the Great tit (*Parus major*; Kluyver & Tinbergen 1953) or the Tawny owl (*Strix aluco*; Southern 1970).

According to Lack (1944, 1949), birds find the suitable habitat primarily due to genetically coded reactions, induced by the stimulations of their environment. Basic theoretical models of habitat selection indicate that, at equilibrium, individuals should distribute themselves among patches in an ideal free or ideal despotic distribution, depending on local density and frequency-dependent effects on fitness and on the type of competition (Fretwell & Lucas 1970). This implies that individuals use some knowledge of environmental quality to choose among habitat patches on the basis of their current relative quality (Wiens 1976). Early theoretical work in behavioural ecology assumed that individuals possessed information about their environment (Valone & Templeton 2002), but recent trend has been to focus more on information acquisition and decision-making. According to the recent public information hypothesis, some animal species may monitor the current reproductive success of conspecifics to assess local habitat quality and to choose their own subsequent breeding site (Valone & Templeton 2002), but current evidence that individuals cue on public information in breeding habitat selection is only correlative and thus cannot be used to reject that individuals use some other cues of habitat quality that are linked to reproductive success of conspecifics (Doligez et al. 2002).

That's why, and because environmental characteristics in natural habitats are managed to an increasing extent, knowledge on types and characteristics of habitats preferred by different species must be taken into account in order to be able to predict the effects of habitat alterations on the population of these species (Pulliam & Danielson 1991).

In Europe and the western part of Asia the most typical habitats of the Black Stork are old, unmanaged forests in the vicinity of rivers, creeks, deltas or other types of wetlands (Cramp & Simmons 1980). Among these, floodplain forests can characteristically be found. According to Lebedeva (1959) the Black Stork has no forest type preference, as it is found nesting in deciduous, coniferous and mixed forests alike. These forests consisted of tall trees, rich in light, poor in bushy vegetation, far from human settlements. Nests built on *Fagus sp., Quercus sp., Alnus sp. Populus sp., Betula sp., Salix sp*. and *Pinus sp*. were as well found. Some researchers regard the Black Stork a forest nester, which can find optimal conditions in different forest types of the Euro-Syberian region. It does not avoid the vicinity of other bird species, its nests were often found nearby e.g. different heron and cormorant colonies in Russia (Dementev & Gladkov 1951), or in the close vicinity of Griffons (*Gyps fulvus*) and Egyptian Vultures (*Aegypius monachus*) in Spain (Szabó pers.comm.) and Turkey (pers. obs.).

In Mongolia (Cramp 1966, Siegfried 1967), the Caucasus (Dementev & Gladkov 1951), Malawi (Ryder & Ryder 1978), South Africa (Siegfried 1967, Tarboton 1982), Zimbabwe (Cannell et al. 1996) and Zambia (Aspinwall 1996) all known Black Stork nests are built on rocks. According to Gonzales & Merino (1988), nesting on rocks is a secondary adaptation e.g. in Black Storks of the Iberian Peninsula, which developed as the forests disappeared. Rock-based nests can often be regarded as a better alternative compared to tree-based ones, which alternative is used by the species in all regions of the range where the possibility is given[5]. In Bulgaria for example, the proportion of rock-based Black Stork nests grew considerably in the past few decades, and this period exactly coincided with the intensification of forest exploitation in the country (Petkov et al. 2006).

Black Storks sometimes use nests built by other species, most often by raptors; as it is already mentioned by Cramp (1966). In Africa, Siegfried (1967) and Tarboton (1982) describe breeding of the species in the rock-based nests of Harrier Hawk (*Polyboroides typus*) and Verreaux's eagle (*Aquila verreauxi*). In Turkey, also on rock, the nest of Egyptian vulture was used by Black Stork (pers. obs.). In trees, in the right-bank floodplains of the Morava River in Austria, a pair of Black Stork bred in the nest of Greylag Goose (*Anser anser*) built very low above ground in *Salix alba* (pers. obs.), furthermore in Hungary, in Gemenc several cases of using the nest of Common Buzzard (*Buteo buteo*), Goshawk (*Accipiter gentilis*) and White-tailed Eagle (*Haliaeetus albicilla*) were observed (pers. obs.).

As in temperate Europe, and thus in the study area the Black Stork is a tree nesting species in old-growth forest (e.g. Cramp 1977, Haraszthy 1984, del Hoyo 1992, Löhmus et al. 2005), degradation of forests, which has been an important issue in biodiversity conservation recently (e.g. Meffe & Carroll 1994, Hunter 1999) is considered one of the major threats for the species on its breeding grounds (e.g. Profus 1994, Tamás & Kalocsa 2005, Löhmus et al. 2005).

The aim of this section is to aswer:

- What the typical characteristics of Black Stork nesting sites in Central Europe/the Pannonian Central Danube floodplains are?

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[5] Szabó J. MS thesis, Szeged University 2001.

- Is the degradation of old-growth forests a real threat to nesting sites in temperate Europe, and in Hungary?
- What can be done on order to secure suitable Black Stork breeding grounds?

1.5.2 Diet and feeding places of the Black Stork

To determine what the most important factors which implied the decline of long-distance migrant birds are in recent decades, knowledge on feeding ecology is essential (Chevallier et al. 2008). In recent years, behavioral ecology has placed considerable emphasis on understanding the adaptive basis of diet choice and factors which influence which foods are selected from an available array (Pierotti & Annett 1990). The food that parents provide to their young is the most important environmental factor influencing reproduction success of many bird species (Martin 1987, Kosicki et al. 2006). An effective Black Stork conservation strategy must also rely on the diet and feeding ecology of the species throughout the whole annual cycle (Chevallier et al. 2008). This way, research on the feeding habitat types used by the species, as well as knowledge about the constitution of its diet, are important, but not very extensive to date. Prior to the start of this study in 1996, no published data on the diet of young Black Storks was available.

In the present chapter, I'd like to determine:

- What is the preferred and/or available diet of the Black Stork during the breeding season?
- What type of food breeding Black Storks provide for their young?
- Is the diet and/or available prey during migration is similar to that in the breeding season?
- What are the characteristics of a typical feeding habitat for the species?

1.5.3 Reproductive success

For the long-term sustainability of a bird population, good breeding conditions and high enough number of young are vital (Krebs 2001). In conservation, one must have a good inventory of all natural and human effects in influencing these, in order to develop a suitable conservation strategy.

Breeding success of birds can be assessed through several parameters. Among these, the number of eggs laid, the number of young hatched and fledged, their condition and the timing of breeding are probably the most important ones. Many studies have targeted the factors that affect breeding success of birds, among these a considerable effort was put into the investigation of the impact of weather, and habitat conditions.

Studies revealed that high precipitation in the breeding season, during the nursing period can have a considerable negative effect on the number of fledged young, e.g. in falcons (McDonald et al. 2004, Mearns & Newton, 1988), other species of storks (Tortosa & Castro 2003, Jovani & Tella 2004, Denac 2006; Lawrence & Robinette 2008) and cranes Ivey & Dugger (2008). Some studies which dealt with the effects of temperature also, showed that cold weather may significantly hinder the success of young to survive to fledging, in very different bird species, e.g. in Capercaillie *Tetrao urogallus* (Moss et al. 2001), Greater Sandhill Crane *Grus canadensis tabida* and White Stork *Ciconia ciconia* (Tortosa & Castro 2003).

Apart from weather, another, but sometimes correlated condition is the status of the habitat, especially with regard to the abundance of food resources. This question was targeted, just to mention a few examples in Prairie Flacon *Falco mexicanus* by Steenhof et al (1999), in Imperial Eagle *Aquila heliaca* by Horváth et al. (2010) and Wood stork *Mycteria americana* by Ogden et al (1978). Griffin et al. (2008) examined hydrological processes of the habitat of Wood Storks as the main factor influencing food conditions, thus having an effect on breeding success, and so did Zduniak (2010) in a floodplain habitat of Hooded Crows *Corvus cornix*.

Based on earlier knowledge it seems that weather and the abundance of prey would together explain a significant part of variance in the number of fledged young. No published study on Black Stork breeding success with aspects on weather or other hydro-meteorological factors is available to date[6], thus I examined what kind of effects do these factors have on the success of breeding (the number of fledged young) in the study area. Given the very high sensitivity of the Black Stork to human presence in early phases of breeding, data are very scarce on the number of eggs laid and hatched. However, for this species, as in many raptors, a widely used parameter to assess the success of breeding is the number of fledged young (e.g. Löhmus et al. 2005, Treinys et al. 2008).

At least 6000 Black Stork pairs breed in temperate zones of Central and Eastern Europe, which means at least the half of the European breeding population of the species is subjected to similar climatic effects.

Given the Black Stork prefers remote and hardly accessible sites for nesting, extensive studies of the breeding ecology, reproductive success and nest failure are quite rare, however, it is alarming that the decline in population numbers is reported from more eastern European countries, and makes it important to understand the factors which influence the breeding success of the species for an effective protection strategy on the long run. In their study to find possible reasons of the declining of the population of the Black Stork in Estonia Rosenvald & Löhmus (2003) conclude that disturbance and landscape change due to forestry operations are probably not responsible for the recent decline of the Black Stork population in their country, but they have not dealt with weather effects.

The questions to be answered are the following:

- What is the breeding success of the Black Stork in 15 years from 1996 to 2010 in Gemenc, Hungary?

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[6] Tamás E., Kalocsa B. The effect of hydro-meteorological factors on the reproductive success of the Black stork Ciconia nigra (*in press*)

- Will the success of breeding be lower if there are less young fish in the traditional feeding places, i.e. does this mean a food shortage?
- What is the effect of high waterlevel is summer, when there is no possibility for the adults to easily access food during the breeding season, on breeding success?
- What is the effect of adverse weather, i.e. much rain and cold in the breeding season?

1.5.4 Survival rates and longevity

In population dynamics, the determination of survival rates is very important. Survival may be influenced by numerous factors, among which breeding success, the status of the habitat used during migration and wintering circumstances all play important roles, as shown for some long-distance migrant species (e.g. Boyd & Piersma 2001).

For the Black Stork, no survival rate estimation was published prior to the start of this study in 2010, this might be due to the fact that ringing activity and recovery numbers in general are still relatively low for the species. It has been reported by different publications (Sellis 2004, Strazds 2004, Tamás, Kalocsa et al. 2006) that the population of the species in the Baltic countries is decreasing, supposing the deterioration of habitats and human impacts in breeding territories and feeding places cause the decline. At the same period in Germany and France (Villarubias et al. 2004, Janssen et al. 2004) the increase of the population is reported, and in the 1980's the species started to re-colonise territories in Belgium, Luxembourg and Danmark, from where it had previously been extinct (Janssen et al. 2004). So far, nobody examined population changes in details, there only were estimates based on the census of breeding pairs which is highly influenced by activity of volunteers in certain areas (Kalocsa & Tamás 2010). For an effective population study, as a start, survival rate determination is vital.

In my study, I am asking the following questions:

- Is it possible to determine how long do Black Storks live?

– What survival rates prevail?

1.5.5 Dispersal

Dispersal of birds refers to the movement of individuals away from an existing population. Through moving from one habitat patch to another, the dispersal of an individual has consequences not only for individual fitness, but also for population dynamics, population genetics, and species distribution (Dunning et al. 1995, Hanski & Gilpin 1997, Hanski 1999). Understanding dispersal and the consequences on an ecosystem level requires understanding the type of dispersal, the dispersal range of a given species, and the dispersal mechanisms involved.

Natal dispersal is the movement of an individual between the natal place and the place of its first breeding, while breeding dispersal is the phenomenon when a breeding bird is shifting its breeding territory (Clobert et al. 2001). There is evidence that natal dispersal is a predictor of recent trends, with species with high natal dispersal experiencing smaller population declines than species with low natal dispersal: the higher the natal dispersal, the larger the ability to shift spatially when facing changes in habitat (Jiguet et al. 2007).

For the Black Stork, as knowledge of individual movement only started to develop with the spreading of colour ringing activities in the second half of the 1990's, no dispersal study has yet been published[7]. In this section, I'd like to show on what area do the ringed birds disperse when reaching breeding age. I try to answer the following questions as well:

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[7] Tamás E. A., Strazds M., Baillon F., Dolata P.T., Jadoul G., Kalocsa B., Karaska D., Karcza Zs., Mikuska T., Pojer F., Sellis U., Stoncius D., Zielinsky P., Zuljevic, A.: The dispersal of the Black Stork (*Ciconia nigra*) in Europe based on colour-ring readings (in prep.)

- At what age Black Storks start breeding?
- Where do second and third year /immature/ birds spend their second summer?
- Do young birds return close to their natal area/nest to breed (what is the rate and pattern of natal dispersal)?
- Are the adults confident to their breeding area/nest (what is the rate and pattern of breeding dispersal)?

1.5.6 Migration

Many land birds migrate long distances. Approximately 1800 of the world's 10000 bird species are long-distance migrants (Sekercioglu 2007). Migration is marked by its annual seasonality (Berthold et al. 2001). The most common pattern involves flying north to breed in the temperate or Arctic summer and returning to wintering grounds in warmer regions to the south.

The Black Stork is a long-distance migrant. Black Storks fly on the daily average 5-6 hours, while the daily distance covered during migration is around 500 km[8] based on the data of satellite tagged individuals (pers. comm. Jadoul). Distances between breeding grounds and wintering places can be 6000 km (Latvia), averaging 4500 km (Czech Republic) on the Eastern Route. On the Western part of the range, the longest routes are around 4000 km (Belgium), while the shortest are around 3000-3500 km (Spain).

Most migrations begin with the birds starting off in a broad front. In some cases the migration may involve narrow belts of migration that are established as traditional routes termed as flyways. These routes typically follow mountain ranges or coastlines, and avoid geographical barriers such

[8] The known maximum is 745 km during a day, which was accomplished by a satellite tagged Black Stork („Lou”) in 2005.

as large stretches of open water. Some large broad-winged birds rely on thermal columns of rising hot air to enable them to soar. These include many birds of prey such as vultures, eagles, and buzzards, but also storks. The specific routes may be genetically programmed or learnt to varying degrees. The routes taken on forward and return migration are often different[9] (Newton 2008).

A considerable part of **Asian** Black Stork populations (from Mongolia, eastern Russia and China) crosses the Himalayas at lower regions, from eastern or western direction migrates to India, and winters there (Pande et al. 2006). In the eastern Russian regions, autumn migration takes place from August to November, with a peak in the end of September, beginning of October. Spring migration starts in February and lasts until May, but the majority of breeding adults arrives until mid-March (Roslyakov et al. 2004).

The **African** population, breeding in the southern one-third of the continent, migrates northwards, but only to relatively short distances of 2-300 km, and, according to present knowledge, spends the winter south of the Equator (Cannell et al. 1996). It is discussed whether African breeders are a totally separate population from the European ones, or even another subspecies, neither of which theories have enough proof to date. It is not known if Asian population (wintering in India) has any connection to the European or the African one.

European Black Storks use two traditional migratory flyways: the Eastern route, through Turkey and Israel is used, according to estimates, by the 80% of the population, while the Western route through the Pyrenees and Gibraltar is preferred by approx. 15%. The remaining 5% spends the winter in Europe or, as claimed by some authors, migrates through Italy in the direction of Tunisia and Lybia (Janssen et al. 2004). A part of the Black

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[9] In 2005, during satellite telemetry study it happened that an idividual Black Stork flied round the Black Sea: from the eastern direction in autumn and from the west in spring. So far this is the first proven case when the autumn and spring migration route of an individual differed considerably.

Storks breeding in north-eastern-Europe and western-Asia uses the eastern shorelines of the Black Sea to migrate near the Caucasus through Turkey and Israel to Africa. Janssen et al (2004) reports that a high number of Black Storks can be observed using this route. It is supposed that a part of these birds come from the Baltic, other part from Russian and Ukrainian breeding grounds.

Black Storks often suspend their autumn migration for several days, even weeks, supposedly in case they find a suitable refuelling site. Identified (colour-ringed) Black Storks using stopover sites in Israel spent 9 days at the site on the average, with a maximum of 29 days (van den Bossche 1996).

The majority of the central European population leaves its breeding grounds between the end of August and the end of September. On the western route, fall migration takes place from August to October, and the peak is usually around 20th September (Urcun 2004). On the Eastern route, according to the counts carried out in Israel between 1988 and 1995, the start of fall migration is in the beginning of August, and the end is in the end of November. The most Black Storks cross Israel in the second half of September and first half of October (even a daily 1000 individuals, the maximum counted was 1821). Migration peaks of adults and young birds are not the same in Israel, as adults arrive sometimes even 2-3 weeks earlier (pers. comm. van den Bossche).

Spring migration is usually started in February and March. Satellite tracked individuals from the Czech Republic left their African wintering grounds between mid-February and late March (Bobek et al 2004). In some cases, western migrant Black Storks winter more east than the westernmost Eastern migrants[10], and unfortunately there is no direct proof until now, but

[10] It also occured to a breeding pair in the Czech Republic (both of them equipped with satellite transmitters, the female being the most famous Kristyna) that the female migrated west, while the male east, and they wintered separately in Africa.

the possibility of loop migration is given (Bobek et al. 2008, Jiguet et al. 2011).

My goal was to verify and exactify migration routes and the numbers of Black Storks using each of them, in order to be able to determine the most important routes and staging grounds for the Eastern migrant European population of the species, in particular, to answer the following questions:

- What are the routes from Europe to Africa (how many routes exist)?
- What is the ratio of Black Storks using each of these?
- Does a „migration divide” exist, and if yes, where it is?
- Is there a difference in the migration of immatures and adults, and if yes, what is the difference?
- Can most important stopover places be identified?
- What are the characteristic features of Black Stork stopover sites?
- What are the threatening factors during migration and at stopovers?
- Do Black Stork learn and remember their migration route and stopover places?

2 Materials and methods

2.1 Nesting site selection

For the determination of nesting site characteristics, fieldwork was carried out from 1992 to 2010, in the Pannonian Central Danube Floodplains in Hungary, Croatia and Serbia. In all three countries it included gathering of data on local distribution, characteristics of nest sites, numbers, breeding habits and threatening factors.

Black Stork nests were mapped every winter. Nest mapping was carried out on the basis of preliminary identification of potential breeding areas, with visual observation. Every winter, given nests are most visible in the deciduous forest in this time of the year, and also because there is no risk of disturbance, the whole area was surveyed walking in approx. 100x100m grid with the participation of volunteers (e.g. Kalocsa & Tamás 1996b, Treinys et al. 2008). During nest mapping and data collection each found Black Stork nest in the study area got numbered and located on a map. The location and status of each Black Stork nest, a. The species of the nest supporting tree, the shape of each tree, the placement of the nests, the size of the tree (circumference), and the height of the nest platform above ground was recorded (Kalocsa & Tamás 1996b, Löhmus et al. 2005, Treinys et al. 2008). Around the nest, in 30 m radius circles, all tree species were determined and their circumferences were measured as well, for better estimation of forest type (constitution), flying corridor and nest coverage/visibility (Pojer 1996, Strazds et al. 1996, Löhmus et al. 2005).

2.2 Individual marking

Since the beginning of the 20th century, the ringing of birds was used to determine e.g. migration routes, differences in migratory behaviour, orientation and navigational studies, movement patterns and their variations (Wayne & Shamis 1977, Bairlein 2001). Ringing in bird migration studies requires international collaboration and co-ordinated continent-wide and long-term studies both for science as well as for the effective protection of migratory birds. (Bairlein 2001). Colour ringing is an effective way of bird marking, as ring reading of live birds produces many recoveries, which are less biased than usually dead recoveries of only metal-ringed individuals (Wayne & Shamis 1977, Calvo & Furness 1992).

The international Black Stork colour ringing programme is going on with the participation of 25 countries[11]; co-ordinated before 2001 by Juan J. Ferrero[12] from 2001 to 2010 by Willem van den Bossche[13], and from 2011 by the author. In Central Europe, particularly in the Czech Republic, Poland and Hungary, the intensity of ringing this species is high (e.g. Kalocsa & Tamás 2002c, 2004a, 2004c, 2005, 2007, 2009a, 2010, Pojer 2009, Tucakov et al. 2006). In Black Stork colour ringing, we use individually coded 3 and 4 digit plastic rings and standard ornithological rings, both put on tibia (as it very often happens that Black Storks are seen wading in water, this helps a lot in identification, furthermore rings put on the tarsus become worn and broken earlier, due to the constact contact with mud and gravel). The coding of colour rings allows for identification of the country of

[11] Austria, Belarus, Belgium, Luxembourg, France, Bulgaria, China, Croatia, Czech Republic, Russia, Estonia, Germany, Hungary, Israel, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Serbia, Slovakia, Spain, Ukraine, Zimbabwe

[12] ADENEX, Spain

[13] WI / IUCN SSC Storks, Ibises & Spoonbills Specialist Group, Natuurpunt, Belgium

ringing (first or first and second character), and the individual identification of the bird (all 3 or 4 characters).

Apart from a very few exceptions (hand-reared or rehabilitated birds and a few adults) all Black Storks were ringed as pulli. In Hungary, we have focussed ringing activities to cover all traditional breeding areas as much as possible (Kalocsa & Tamás 2002c, 2004a, 2004c, 2005, 2007, 2010, fig. 4).

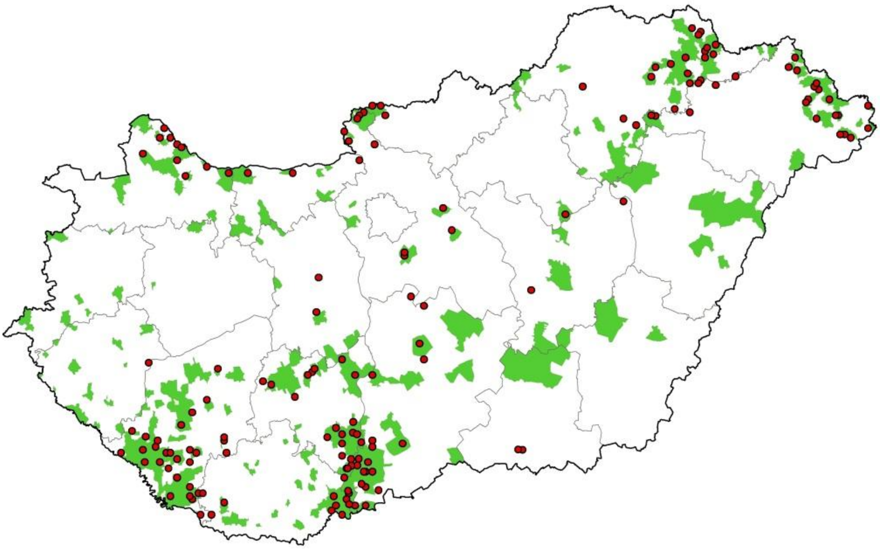

Figure 4. Most important Black Stork breeding grounds in Hungary (green), and locations of colour ringing (red); 1992-2010.

Recently, new tools such as satellite telemetry emerge enabling more sophisticated studies of migration (Bairlein 2001). Satellite tracking has already been used as a new conservation concept for migrating storks, providing opportunities for bird protection and scientific work (Kaatz & Kaatz, 1995). This technique is already used to identify assembly points, resting areas and risk factors along migration routes of white C. ciconia and black storks (Berthold et al. 2001, Bobek et al. 2008, Chevallier et al. 2008).

In frame of an international project[14], two adult Black Storks were captured in Hungary using special traps, then ringed and fitted with a satellite transmitter (PTT platform with harness, 70 g), before being released. Locations were obtained for each bird and evaluated based on confidence indices, which were provided by the Argos system (from higher to lower quality codes of location estimates: Location Class (LC) 3-2-1-0-A-B). The locations were mapped using a Geographical Information System (ArcGIS 9.3; ESRI).

2.3 Diet

The food of nestlings was determined in Hungary, Croatia and Serbia from years 1996 to 2010. As Black Stork nestlings are regularly ringed in frame of the International Black Stork Colour Ringing Program, this was done by collecting food remains and regurgiated food during ringing of the youngs.

When youngs are handled for ringing, they typically regurgitate, so that food items can be identified (Pierotti & Annett 1990). It is a widespread method to assess prey selection in raptors and storks to use the regurgitated or uneaten food items found at the nest for the determination of diet composition (e.g. Putzig 1935, Drescher 1936, Szijj & Szijj 1955, Sackl 1987, Kosicki et al. 2006, Tornberg & Reif 2007). It is however true that these kind of data are often claimed to be biased, because remains of different prey items may be preserved in the nest inequally (e.g. Rutz 2003, Lewis et al. 2004). Despite this, the method is frequently the only possibility and gives the only reliable data on the diet of certain species (Tornberg & Reif 2007), and in some comparative studies this type of analysis has given

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[14] FlyingOver Natura2000, EC grant No 07.040200.00/2004/393583/SUB/B2

results fairly similar to direct methods (e.g. Collopy 1983, Simmons et al. 1991) and, based on recent literature and our own experiences, this is also true for the Black Stork (e.g. Hampl et al. 2005). It is generally accepted that the use of food remains and pellets is the most reliable way of getting information about the food of nestlings for raptors and storks, without extra disturbance or much increased costs (Collopy 1983, Simmons et al. 1991, Redpath et al. 2001, Tornberg & Reif 2007, Kosicki et al 2006). After the identification of the prey, species and size was recorded and the food was placed back in the nest for the young to eat.

Visual observation, to be used as a supporting method to prey remains analyses, was also carried out in the known feeding places, and when possible, the prey species caught by the Black Storks was determined by watching through a telescope.

Feeding places were located in the Central Danube Floodplains area (pers. obs.), and along migration routes (Eastern route – Tamás & Kalocsa 2005, Bobek et al. 2008, van den Bossche 1996, Western route - Bobek et al. 2008, Chevallier et al. 2011) and wintering sites (van den Bossche 2004, Bahat 2008, Bobek et al. 2008, Chevallier et al. 2008) as well. In a few instances, satellite tracking provided us with co-ordinates of the location of feeding places.

The analysis of collected food samples was carried out, and was compared to the results of visual observation at feeding places as well as data in other publications.

2.4 Reproductive success

Until 2010, altogether more than 200 Black Stork nests were located in Gemenc. There are on the average 80 nests recorded in good condition yearly in 180 km^2 of floodplain. All the existing nests were checked at least once every year for occupancy, and a nest was considered occupied when at least some nest building occured in that year (Löhmus et al. 2005). The number of breedings started was assessed by visual observation of at least one of the adults guarding the nest in late April – early May, as one of the adults is always on the nest from the laying of the eggs until the young grow up to approximately 6 weeks of age. We avoided visiting the nests before May, because of the high sensitivity of the species to human presence before the laying of the eggs. This way, it was not possible to record the number of eggs laid. All the years from 1996, all nests in which a breeding started were re-visited in June-July, not much before fledging, in order to determine success of breeding (count the young) and to ring the young. Productivity was measured, as in most raptors and other studies of the Black Stork, as the mean number of large, well-feathered young per successful breeding (e.g. Korpimaki 1984, Löhmus et al. 2005, Treinys et el. 2008).

The basic data on the reproductive success collected during fieldwork were analysed. The dependence of the number of youngs on the hydrological regime of the river Danube (Kalocsa & Tamás 2004b), and hydro-meteorological factors were analysed with statistical methods in the present study. In my present study I used daily morning waterlevel data for the Baja gauge[15]; the daily mean air temperature data for the Baja[16] and Szeged[17] meteorological stations; furthermore the daily precipitation data measured at the Baja station[18].

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[15] Danube 1478.9 rkm, zero-point 80.99 m asl

[16] 46°10'50"N - 19°0'40"E

[17] 46°15'21"N - 20°5'24"E

[18] All the hydro-meteorological data series are available for download from the Hungarian Hydrological Databank (www.vizadat.hu) and from the homepage of the Hungarian Meteorological Service (www.met.hu).

2.5 Survival rates and longevity

Altogether more than 7000 Black Storks have been colour ringed worldwide (pers. comm van den Bossche), out of which 1069 individuals in Hungary (~15%), which fits with the criterion of the minimal sample size according to Krejcie & Morgan (1970). The number of resightings is the highest in Hungary among all European countries, supposedly because of the high volunteer activity and the favourable geographical location of this country, with lots of Black Storks migrating through it.

In the present study I used the databases of EURING (all Black Stork recovery data until November 2009) and the Hungarian Bird Ringing Centre (all Black Stork ringing and recovery data until November 2009).

Current methods for estimating age-specific survival rates from the ring resightings of birds depend critically on a number of assumptions. Even if these assumptions hold, current estimating procedures require the imposition of a constraint. The need for the constraint arises, in the first place, because the generally used design of field observations is inadequate to provide sufficient biological information to estimate the parameters of interest. Because survival probabilities of birds are believed to become „constant" with increasing age, a commonly used constraint is that the survival probabilities in successive age-groups of older birds are equal. The constraint achieves mathematical tractability but does not necessarily give reliable survival estimates, no matter how many birds are ringed (Lakhani & Newton 1983). Ideally, to estimate age-specific survival rates, the age of every ringed bird should be known (Lakhani 1987), but previous analyses have also shown that models for birds ringed as young can be used to test even complex variation in survival rates, provided that recovery rates do not vary with age (Francis 1995).

I analysed the resightings of Black Storks colour ringed in Hungary, determining their recovery rate, the changes in recovery rate in time, furthermore the survival rates based on resightings of ringed individuals. For the analysis of survival, only the Hungarian database was used, because the total number of individuals ringed yearly is not exactly known for the other schemes.

2.6 Dispersal

The study on the dispersal behaviour of the Black Stork is based on colour ringing and colour ring identification. In this section, recoveries in the datasets maintained by colour-ring co-ordinators in European countries were used, obtained during personal communication from Belgium (Jadoul G.), Croatia (Mikuska T.), Czech Republic (Pojer F.), Estonia (Sellis U.), France (Baillon F.), Latvia (Strazds M.), Lithuania (Stoncius D.), Poland (Dolata P.T. & Zielinsky P.), Serbia (Zuljevic A.), Slovakia (Karaska D.) and the database of the Hungarian Bird Ringing Centre.

Efforts for the identification of oversummering and nesting individuals are made in many countries of the range of the Black Stork (including Estonia, Latvia, Poland, Czech Republic, Germany, Croatia and Hungary). This means that after the beginning of incubation an observer is sitting at the known nests in a hide, safe distance from the nest to avoid disturbance, and waits until both adults are seen (they take turns in 3-4 hours in incubation and later in guarding the nest; pers. obs.).

Apart from adults on nests, the vast majority of observations were made at feeding places.

In the following, I determined distances and directions of recoveries, grouped according to age and proof of breeding, and analysed them in a GIS. Groups were as the following:

(1) Non-breeding, subadult birds (2 and 3 cy) observed in the breeding range.

(2) Adult age (3+) birds observed in the breeding range, in the breeding season (April to July), but not on nests. Possibly migrating individuals (recorded before 1 April and after 31 July) are excluded. Group 2 are considered breeding in the close vicinity of these observations.
(3) Birds observed nesting (identified on the nest, incubating or rearing young). These are proven breeders.

Because of the difficulties in sexing Black Storks (no dimorphism), separation according to sexes is not yet possible, as there are too few ringed individuals with known sex.

2.7 Migration

I used satellite tracking data of Black Storks to determine the main migration routes in a GIS. I added already published, earlier findings of satellite tracking (Bobek et al. 2008), as well as recoveries of European Black Storks during migration and wintering as points to the dataset. I summarized all available migration count data in order to be able to estimate the proportion of the European Black Stork population using each route.

2.7.1 Migration counts

Migration counts are conducted in major places within the range of the Black Stork, along the known migration routes on the East, the West and in the Mediterranean. I collected the latest available information from publications and personal communication with the organizers of such kind of surveys, furthermore I participated the countings at the Bosphorus

Straits (Turkey, Istanbul) in 1999, 2001, 2003-2010; and at the Belen Pass (Turkey, close to the Syrian border) in 2009 and 2010.

2.7.2 Ringing data

Recovery analysis of the data of the EURING databank and the Hungarian Bird Ringing Centre was carried out.

2.7.3 Satellite telemetry data

To date, Black Storks have been equipped with satellite transmitters in the Eastern European range in frame of three different projects. The results of these are partly available on-line and in forms of publications, in case of the African Odyssey (Bobek et al. 2008) and EagleLife[19] projects.

The aim of the **FlyingOver Natura 2000** project was to introduce the areas of Natura 2000 through "postcards" sent by Black Storks when passing these. In the course of the whole project 20 Black Storks from different countries in Europe were provided with transmitters. Their movements were monitored within almost one year. I personally took part in this project in the catching, ringing and tagging of the storks, and as Hungarian project co-ordinator (Annex 8). Out of the 20 Black Storks tagged in frame of the project, 7 individuals turned out to be Eastern migrants (1 Czech, 2 Estonian, 2 Latvian and 2 Hungarian birds). I used their data in the determination of routes and stopover places.

[19] http://www.kotkas.ee/ENG/life.html

2.8 Statistical analyses, methods and models used

The mean and standard deviations of parameters were estimated where appropriate.

Shapiro-Wilk test (Shapiro & Wilk 1965) was chosen to test normality of data series.

Nonparametric Mann-Whitney statistics (Mann & Whitney 1947) was used in nest site selection, because of the non-normal distribution of the data.

Pettit's homogeneity test, with a significance level of 5% and 10000 Monte carlo simulations was used to examine hydro-meteorological data series.

In breeding success, in order to test my hypotheses, a multi-variate Partial Least Squares Regression (PLS) model was computed in MS Excel (Wold 1985, Helland 1990). It was chosen because it is a technique which can handle many independent variables, even when predictors display multicollinearity. Furthermore, PLS serves well when sample size is small. A disadvantage of the method is that the distributional properties of estimates are not known, and one cannot assess significance directly from the model outputs. In the PLS, the yearly average number of young was chosen as dependent variable, and hydro-meteorological factors (data series) which were supposed to influence it were chosen as independents (= covariates). The variable representing the deterministic hydrological effect on the abundance of fish was average spring (February to April) waterlevel (MEAN 2-4), because if the waterlevel is permanently smaller than the bottom levels of floodplain channels (H_{mean}<400 cm), fish are prevented from spawning in the floodplain. The variable representing the deterministic hydrological effect on the availability of fish was mean summer (May to July) waterlevel (MEAN 5-7), because if the feeding places are totally dry (H_{mean}<350 cm) or flooded high (H_{mean}>500 cm) during summer the adults are not able to feed in the floodplain. For the impact of weather, 4 variables were used for May and June, while the young chicks stay in the nests: the length of the longest continuous rainy period (LENGTH RAIN), the summa of precipitation (SUMMA RAIN), furthermore the averages of daily mean temperatures for these two months (avg temp may and avg temp june, respectively). The significance level in the PLS model was 95%. I give a summary of the statistical indices of these data series in Table 1.

Table 1. Summary statistics of PLS explanatory variables.

Variable	Unit	Minimum	Maximum	Mean	Std. deviation	Meaning
MEAN 2-4	cm	260	590	383	90.865	Mean spring waterlevel
MEAN 5-7	cm	249	586	419	98.183	Mean summer waterlevel
LENGTH RAIN	d	2	9	4.73	2.02	Length of longest rainy period
SUMMA RAIN	mm	37.0	332.9	136.49	68.56	Precipitation summa
avg temp may	°C	12.29	18.64	15.827	1.590	Mean May temperature
avg temp june	°C	14.71	21.94	19.353	1.808	Mean June temperature

In longevity and survival, I used MS Excel 2007, U-CARE (Choquet et al. 2005) and M-SURGE (Choquet et al. 2004) to do the analysis. In the models the animals are released live at encounter no.1. (ringing), as pulli. Marked animals are encountered live (ring identification) in certain years (1 to 16). Encounter histories of birds are defined in the input file as single records for identical cases. I used 1 group, as it is not possible to make a difference between the sexes (they are not known), and the number of birds reported dead are so low compared to the number of colour ring readings, that I excluded them from the dataset.

3 Results

3.1 Nesting site selection

In the entire study area of the Pannonian Central Danube Floodplains, 72 pairs of Black Storks bred on the average (Table 2) that makes over 10% of the whole Pannonian population estimated to be 715 pairs by BirdLife International (2004).

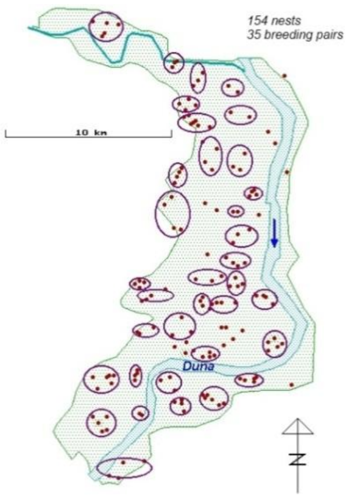

Figure 5. Gemenc area in southern Hungary (central co-ordinates 46°15'18"N - 18°53'18"E), with an indication of 35 supposed Black Stork territories, as in Kalocsa&Tamás (2002a)

The distribution of breeding pairs was not even over the area – the highest number is recorded in Gemenc region with 35 to 40 pairs yearly (fig. 5), followed by the left Danube bank in Serbia (15 pairs) and Beda-Karapancsa region (11 pairs). The lowest numbers of breeding pairs are recorded along the right Danube bank in Croatia with only eight pairs.

Table 2. Results of mapping of Black Storks Ciconia nigra nests and pairs breeding in central Danube floodplain

Parameter	Gemenc	Béda – Karapancsa	Danube right bank (Croatia)	Danube left bank (Serbia)	Total
Number of located existing nests	70	28	32	31	186
Number of located breeding pairs	38	11	8	15	72

The nesting substrate was similar along the whole area (Table 3). The importance of stands of Quercus robur and Populus alba/nigra is clearly visible since 87% of the nest was built on these tree species. 94% of all nests have been situated within natural or semi-natural mixed stands of native tree species, while only 6% were found in planted stands of non-native tree species as *Populus euramericana, Juglans nigra, Acer negundo*, and *Robinia pseudoacacia*.

Nests were situated from 6 to 31 m above the ground. Black Storks were nesting almost exclusively in old, natural forest stands that were near the end of their exploitation cycle. Within the stand, they were selecting old, large trees.

The mean circumference of nesting trees, measured in Croatia and Hungary was 2.53 m (n=123, SD±0.77 m). For comparison, the circumference of the trees around the nest tree was also measured. The Mann-Whitney statistics showed that the circumference of nest trees and surrounding trees differs significantly ($p < 0.001$), where the latter was only 1.55m (n=354, SD±0.63). This indicates that Black Storks prefer larger, i.e. older trees for nesting.

Table 3. Host trees for nests of Black Stork in the Central Danube floodplain (N=264), as in Tucakov et al. (2006).

Tree species	Gemenc	Béda – Karapancsa	Danube right bank (Croatia)	Danube left bank (Serbia)	Total
Quercus robur	96 (67%)	30 (71%)	16 (53%)	24 (55%)	166 (63%)
Populus alba	29 (20%)	7 (17%)	10 (32%)	15 (34%)	63 (24%)
Populus nigra	2 (1%)				
Fraxinus angustifolia	7 (5%)	2 (5%)			9 (3%)
Ulmus laevis	1 (1%)	2 (1%)			3 (1%)
Ulmus sp.			2 (6%)		2 (1%)
Quercus cerris				2 (5%)	2 (1%)
Salix alba	1 (1%)				1 (0%)
Pyrus pyraster				1 (2%)	1 (0%)
Juglans nigra		5 (2%)	1 (3%)		6 (2%)
Fraxinus pennsylvanica	4 (3%)			1 (2%)	5 (2%)
Fraxinus sp.			2 (6%)		2 (1%)
Populus euramericana	2 (1%)				2 (1%)
Acer negundo	1 (1%)				1 (0%)
Robinia pseudoacacia				1 (2%)	1 (0%)
TOTAL	143	46	31	44	264

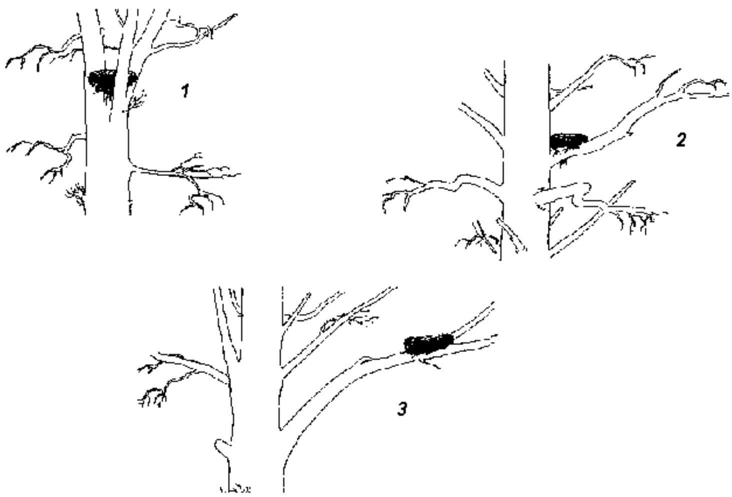

Figure 6. Most typical placements of Black Stork nests on trees in the study area, as in Kalocsa &Tamás (2002a)

This may be explained by the fact that the placement of the nest and the size of the supporting branch can have a very important role in the stability of the nest. The nests are situated most frequently on a (nearly) horizontal branch (fig. 6, type 2), close to the trunk (37 %), on the brach more than 1 m from the trunk or on a fork (fig. 6, type 3) of a horizontal branch (42 %).

Sometimes the nests are placed in a crotch (fig. 6, type 1; 18 %) and very rarely, if the tree is bent down, the nest can be placed on the horizontal or almost horizontal part of the trunk itself (3 %). Black Stork nests are built very large (approx. 1.2-1.5 m in diameter and tens of centimeters in height, pers. obs.), thus their weight, particularly when wet, can be significant. It often happens that nests built on younger i.e. smaller trees, the nests fall down in storms, often causing also the breeding to fail.

3.2 Diet and feeding places of the Black Stork

Black Storks are present in the study area from March to October, during breeding season in relatively smaller numbers. Bigger groups can be observed during migration, mostly in August and September. They gather mostly in shallow, fish-rich feeding places. Summering, non-breeding Black Stork flocks can also be regularly observed in the Gemenc area and the surrounding. They always visit the almost dry, shallow water bodies which are rich in fish, so are in favorable condition for Black Storks (Kalocsa & Tamás 2003).

I analyzed an 8 years' data series about the food of young Black Storks (Table 4). It can be seen that during 8 years, from 419 pieces of carcasses (Kalocsa & Tamás 2002b, 2004b, Tamás & Kalocsa 2006). During my studies I found that in the diet of young *Carassius auratus*, *Esox lucius* and *Cyprinus carpio* prevail, their percentage is altogether 52%. All other species of fish were found in 12%, which means 64 % of the food collected by adults was fish. Amphibians and reptiles were found in 35 %, the rest (larvae of dragonflies) 1%. Also supported by visual observations at feeding places in the area, *Esox lucius, Carassius auratus* and *Misgurnus fossilis* are the most frequently caught fish species by adults. The adults collected up to 10-15 cm long specimens depending on the age of young (Kalocsa & Tamás 2002b, 2004b) and this coincides with other studies listed by Cramp (1977) and Janssen et al. (2004).

Table 4. Diet choice of the Black Stork based on a 8-year study at nest

SPECIES	PIECES	%
FISH		
Abramis brama	24	4,91
Abramis sapa	2	0,41
Carassius auratus	110	22,49
Cyprinus carpio	9	1,84
Esox lucius	74	15,13
Ichtalurus nebulosus	3	0,61
Lepomis gibbosus	4	0,82
Misgurnus fossilis	12	2,45
Neogobius fluviatilis	1	0,20
Perca fluviatilis	9	1,84
Pseudorasbora parva	12	2,45
indet. fish	43	8,79
REPTILES AND AMPHIBIANS		
Bombina bombina	8	1,64
Bufo viridis	18	3,68
Rana esculenta	103	21,06
Triturus dobrogicus	1	0,20
Natrix natrix	2	0,41
indet.amphibian	50	10,22
OTHER	4	0,82
summa	489	

Based on these eight years' data the food and feeding place preference of the Black Stork can be determined (for this habitat, or for this type of habitat).

The food of young Black Storks in the study area consists mainly of fish, if they are available, and a bit rarely frogs. Other kinds of prey are very rare.

According to a study carried out in the Czech Republic, in the food of young Black Storks aquatic animals, mainly fish, prevailed in the nestlings' diet. Six species of fish, undetermined frogs and snakes, two mammal species and eight insect species were found (Hampl et.al. 2005).

For feeding habitat preference, apart from visual observations, the data of two satellite tagged adult Hungarian Black Storks were used. One of them was a male (Koppány), the other a female (Margit), both of them breeding birds. The second part of the breeding season was tracked in 2005, and these can also be supplemented with ring recoveries of one of them, which returned in 3 consecutive years to breed at the same place[20]. Feeding site preference was different in the case of the two satellite tagged birds, but both of them showed a high fidelity to one feeding place in the breeding season. Margit was using a remote dead riverbranch 15 km SE from her nest, while Koppány preferred an artificial fishpond 7 km to NNW from the place where he was breeding. As Koppány did not return from migration the next year, there was a possibility to see only where Margit is feeding. She was seen in two totally different riverbranches the next two seasons, 8 km W and 13 km NW from her nest (she was breeding in the same nest for three more years), but the feeding place she preferred in 2005 was unavailable (totally dry) in these years (pers.obs.).

Observations on the Black Storks' feeding habits during migration were made in 3 major areas: the Danube river basin (Pannonian Central Danube Floodplains, pers. obs), Central Anatolia (pers. obs), and in the Jordan valley (pers. comm. van den Bossche, van den Bossche 1996, Bahat 2008).

From October 2002 to December 2003, in frame of a complex monitoring program carried out in part of the Gemenc floodplain, the waterbirds were counted 55 times on Nyéki Dead Branch, which is an oxbow lake of the Danube, serving as feeding place for different waterbird species according

[20] The other bird, Koppány (male) suffered electrocution during migration in Turkey.

to the changes in waterlevel. The number of individuals of different species were recorded. Data about the occurrence of Black Storks are presented here from March to October 2003. During the monitoring period, the waterlevel was also recorded[21].

Altogether 94 bird species were registered at the Nyéki Dead Branch during the period of monitoring. Black Storks were continuously present from March to October. Five breeding pairs are nesting in the vicinity of the oxbow lake.

In the year 2003, the waterlevel of the Nyéki Dead Branch changed in a continuous transition from „lake" status to very shallow, almost dry status (fig. 7). In the presented period, waterlevel decreased from 186 cm to 23 cm (measured above the zero point of the installed temporary gauge).

The dead branch in different states is ideal for different groups of bird species with different needs. The clear dependence from waterlevel can be well seen on fig. 7. While in March no feeding Black Storks were present, in April and May, still with high waterlevel (166 cm) there was only 1, in June 4, in July 5. In the second half of August, with the drastic decrease of the waterlevel (75 to 30 cm), the number of feeding Black Storks increased significantly. In August, 40 Black Storks were feeding here, in September the number of observed individuals was 24, and in October, 3. Until the start of the migration the majority of potential feeding places already dried out. For example, in May 2003, 72 individuals were feeding at another dead branch in Gemenc, Báli lake, but in August this lake was already completely dry and empty, while on the Nyéki Dead Branch ideal circumstances were given (Kalocsa &Tamás 2003), as the big crowds of fish present in the extremely shallow water were easily accessible.

As the preferred diet of the Black Stork consists of fish and tadpoles, I examined what the availability of suitable prey depends on. The spawning time of *Esox lucius* often starts already in February, followed by *Carassius*

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[21] Technical Faculty of Eötvös József College, Baja

auratus and *Cyprinus carpio* in March and mainly in April. The spawning of amphibian species inhabiting the study area coincides with this in time. The possibility of a good spawning of these species is only given if there is a flood on the river Danube (Tamás & Kalocsa 2005), providing water coverage in the floodplain, where shallows and low velocity zones equally develop. In some years the waterlevel is so high even in summer that the storks are unable to wade in the floodplain lakes (Tamás & Kalocsa 2005). In other years, the floodplain may completely dry out until May, and both cases mean adults are forced to a much bigger effort to collect food for their young outside the protected area in ditches, meadows or fishponds.

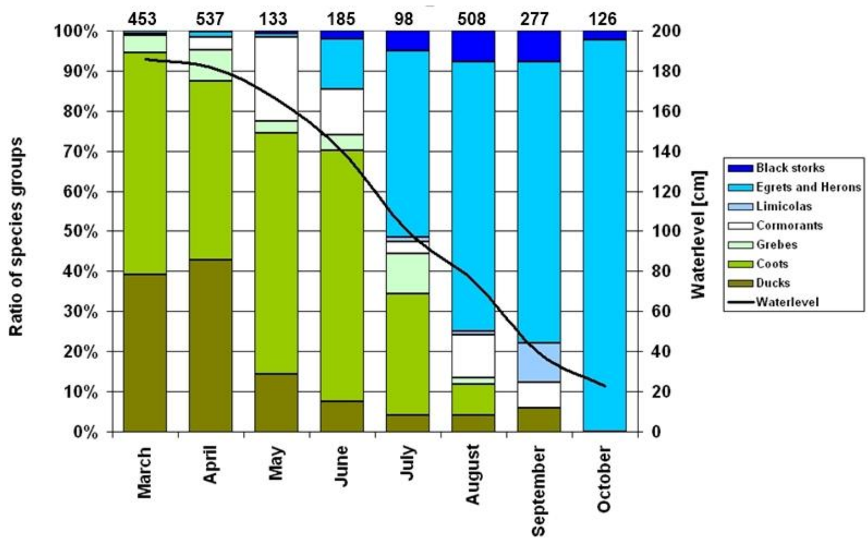

Figure 7. Percentage of bird species grouped by feeding preferences observed at Nyéki dead branch, March-October 2003, with indication of the total number of birds above each column as in Tamás & Kalocsa (2006)

The diet of the Black Stork during migration is very similar to that in the breeding season. In autumn migration stopovers and feeding flocks are quite common, while spring there are no such kind of observations: migration is quicker and is rarely suspended (Bobek et al. 2008).

In Turkey during migration, 3-400 individuals fed daily in certain temporary lakes of Central Anatolia (e.g. Kozanli Gölü), where they were observed year by year in autumn catching solely fish, mainly relatively young individuals of *Cyprinus carpio* (pers. obs).

In Israel, Black Storks on stopover feed in the artificial fishponds of the Jordan valley, and their prey constitution shows a slight difference: although they feed on fish, the species of the prey (big percentage of *Tilapia sp*.) is primarily determined by the species grown in the respective pond (van den Bossche 2004).

The constitution of the diet of course depends much on the species constitution of fish available in the feeding place, but generally fish predominated to all other types of prey, i.e. during migration, and also in wintering grounds, the only observed type of prey was fish (van den Bossche 1996, 2004, Bahat 2008, Chevallier et al. 2008, 2010a, 2010b).

3.3 Reproductive success

The number of occupied nests in the Gemenc part of the study area each year varies from 33 (2001) to 58 (2005), which number may include more than one nests for some breeding pairs, in case a newly built nest was only found in the winter after the breeding. The number of breeding proven to have started was minimum 21 (2006) and maximum 48 (2003). The number of breeding started may have been a little higher, as in some of the nests eggs could have been destroyed during laying, or early incubation, which might be considered here as unoccupied.

The number of breedings which are proven to be successful (from which young surely fledged) ranges from 2 (2010) to 29 (2002). Maximum number of young was 5, recorded several times, but not every year. The year 2000 was exceptional with 9 nests in the study area from which 5 young fledged, and year 2010 was exceptional with the lowest nestling success ever observed in the area (only two nests were successful). As I do not know the number of eggs laid, and also the number of breeding started can be a little different from known, I give the nestling success as the number of young per known successful nests. The yearly average of the number of young Black Storks per successful breeding is shown on fig. 8.

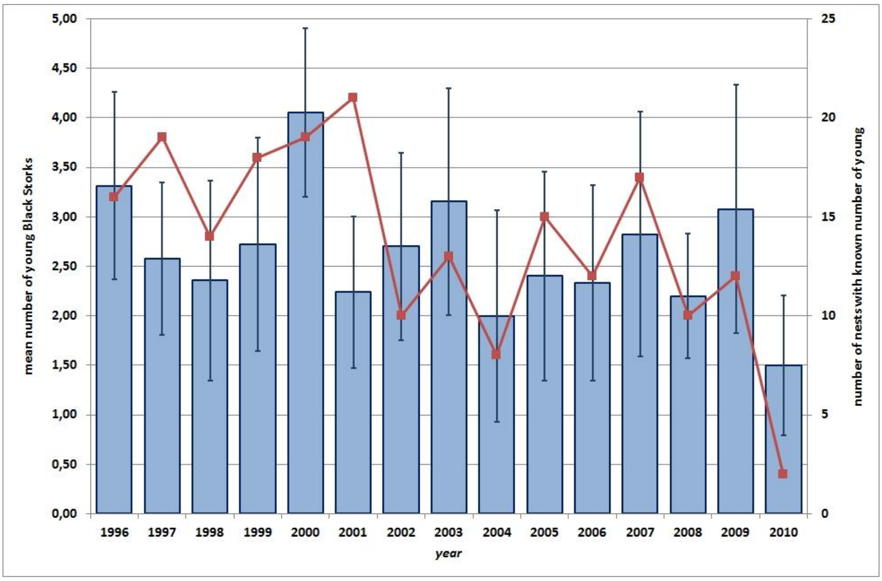

Figure 8. Mean number of fledged Black Stork young per nest (±SD) in the Gemenc region, with the number of known successful breeding per year (red markers), 1996-2010; mean=2.63±0.61 (SD); n=15, min=1.50 (2010); max=4.05 (2000)

I found 3 proven types of reasons for nesting failure, which were predation by bird or mammal (7%), human disturbance (10%), illness/poisoning (1%). Most of the failed nests (82%) however remained without a visible reason for being unsuccessful, and this led us to expect that starving because of the lack of food and the impact of rainy and/or cold weather causing low body temperature (consequently death) of the chicks can have the most important role in these. That is why it is also a question to be answered by my present investigation, if the fish are accessible for the adults to catch during the breeding season.

3.3.1 Results of statistical modelling

For the analysis of the effect of hydro-meteorological factors on breeding success, a Partial Least Squares (PLS) model was computed. The model parameters and the results of the PLS analysis are given in Tables 5 and 6, while the correlations between the number of young and the different explanatory variables are given in fig. 9.

Table 5. Standardized coefficients of the PLS.

Variable	Coefficient	Std. deviation	Lower bound (95%)	Upper bound (95%)
MEAN 2-4	0.147	0.184	-0.215	0.508
MEAN 5-7	-0.011	0.057	-0.123	0.100
LENGTH RAIN	-0.229	0.051	-0.329	-0.129
SUMMA RAIN	-0.246	0.073	-0.389	-0.104
avg temp may	0.187	0.086	0.019	0.355
avg temp june	0.155	0.076	0.005	0.305

Table 6. Model parameters as an outcome of the PLS.

Variable	No. of young
Intercept	1.206
MEAN 2-4	0.001
MEAN 5-7	0.000
LENGTH RAIN	-0.073
SUMMA RAIN	-0.003
avg temp may	0.063
avg temp june	0.046

In Table 7, the Variable Importance in the Projection (VIP) is given. The VIP statistic of Wold (1994) summarizes the contribution a variable makes to the model. According to this, out of the explanatory variables the mean summer waterlevel is not confirmed having a significant effect in the model (VIP<0.8). The variables with the highest effects are precipitation summa, the length of the longest rainy periods and the average temperature in May. In Table 8, the results of modeling are summarized and evaluated.

Table 7. Variable Importance in the Projection (VIP).

Variable	VIP	Standard deviation	Lower bound(95%)	Upper bound(95%)
SUMMA RAIN	1.371	0.148	1.081	1.662
LENGTH RAIN	1.274	0.362	0.564	1.985
avg temp may	1.040	0.321	0.410	1.670
avg temp june	0.862	0.299	0.276	1.448
MEAN 2-4	0.816	0.649	-0.455	2.088
MEAN 5-7	0.063	0.236	-0.399	0.525

Table 8. Results of the PLS modeling and the study for the hydro-meteorological factors influencing Black Stork nestling success.

Factor	Correlation to the no. of young	Importance	Trend in 15 years	Impact in 15 years	Long-term trend in future	Predicted impact
Length of longest rainy period	negative	very high	increasing	negative	possibly decreasing	possibly positive
Precipitation summa in the breeding season	negative	very high	increasing	negative	possibly decreasing	possibly positive
Mean May temperature	positive	very high	decreasing	negative	possibly increasing	possibly positive
Mean spring waterlevel	positive	high	decreasing	negative	decreasing	negative
Mean July temperature	positive	high	decreasing	negative	possibly increasing	possibly positive
Mean summer waterlevel	negative	moderate	increasing	negative	decreasing	negative

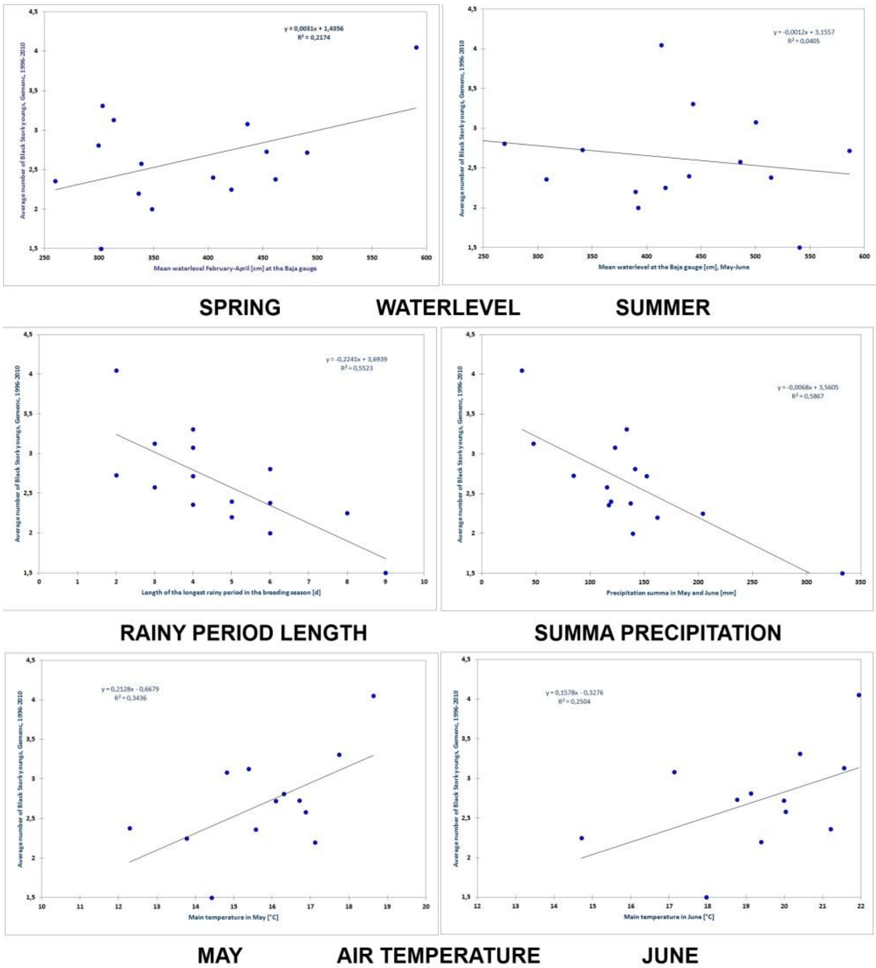

Figure 9. Correlation between the number of Black Stork young and the different explanatory variables

Assessing the effects of all the examined factors yearly, I used „BAD" and „GOOD" intervals for each and every variable examined. I summarized these in Annex 1, considering the following values: (a) spring waterlevel is good if there is at least a partial inundation on the floodplain (H_{mean}>400cm), providing spawning grounds for fish that serve as main food items. (b) summer waterlevel is good if floodplains are not dry, but inundation is shallow enough for Black Storks to wade (350cm<H_{mean}<500cm); (c) rainfall is good if P_{sum}<150mm during 2 months; (d) length of rain is good if rainwater can not accumulate in nests (P_{length}≤3d); (e) temperature in May is good if T_{May}>16°C; and finally (f) temperature in June is good if T_{June}>20°C. Examining the assessment, I find that from the viewpoint of the number of fledglings, year 2000 must have been the best with a flood wave in the spring, medium waterlevel in summer, almost no rain in the breeding season and a hot weather. The opposite is 2010, when waterlevel was too low in spring but too high in summer, and May and June were extremely cold and rainy. This coincides with the number of fledged young, which was the highest in 2000 and the lowest in 2010, in relative and absolute numbers as well.

3.4 Survival rates and longevity

Out of 1378 ringed individuals with at least one recovery in the EURING database, except for 20 individuals all were ringed as pulli. As the number 20 is too low to draw consequesnces for birds ringed at an age different from pullus, I excluded these. The highest known age Black Stork which recovered was an individual from Poland, found dead 19 years after ringing. The second oldest individual was also Polish, found dead at 18 cy. The oldest live encountered Black Storks were 2 individuals encountered at 17 cy, one from Poland and one from Hungary. In the Hungarian database, there are 1069 individuals ringed as pulli. Summarizing the recoveries of all individuals at certain ages, and plotting these against the number of ringed individuals as a percentage, a survival curve can be drawn (fig. 10).

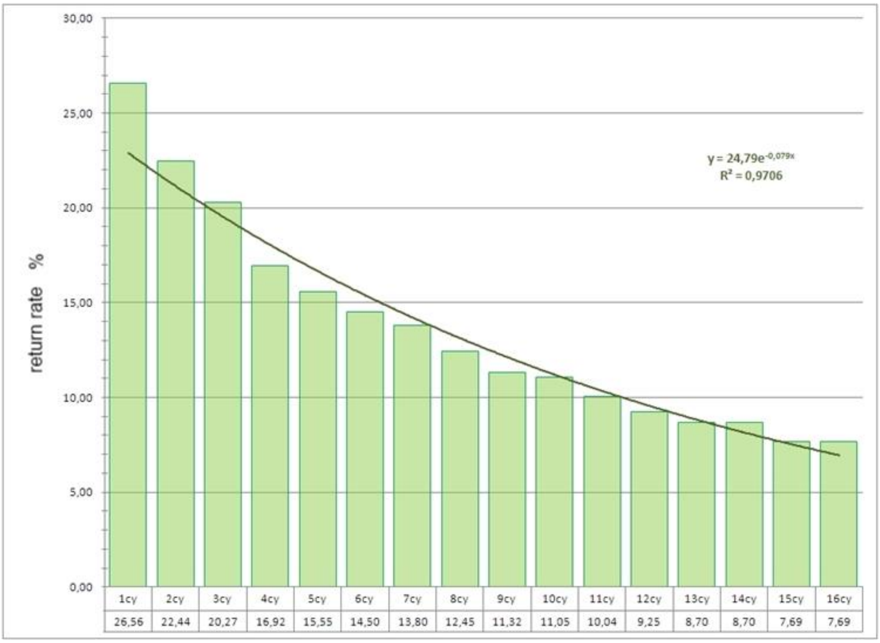

Figure 10. Survival curve of Black Storks calculated directly from ring recoveries, with return rate indicated per calendar year, 1994-2009.

The encounter matrix of Black Storks based on the database of the Hungarian Bird Ringing Centre is given in Annex 2, indicating the number of ringed individuals yearly, and showing how many of these were seen in the same year, and the proceeding years afterwards.

3.4.1 Results of survival modelling

U-CARE (Choquet et al. 2005) goodness of fit test indicated age effect on survival in the case of Black Storks marked as pulli (chi^2=92.972, df=12, p<0.001, TEST3.SR). The Sa2*t, P*t model (which expects different survival for 1 cy and older birds, and the survival of these two age classes, as well encounter rate varies with years) fit to the data (chi^2=28.742, df=34, P=0.723) so this was used as basic general model (Table 9). There is only one supported model, where delta AIC = AIC – min(AIC) < 2.00.

On the basis of the model selection, program M-SURGE (Choquet et al., 2004) showed that S a(1,2), Pt model has the lowest AICc value. This model expects that the survival rate is constant over the years but different for 1 cy birds compared to older individuals, and encounter rate varies over the years. The found significant difference between 1 cy (survival rate: 0.1696, 0.1297-0.219) and older birds (survival rate: 0.838, 0.773-0.887) can be caused by a real difference in survival, however higher permanent emigration of young birds might also have a role in it.

*Table. 9. Results of the model selection, where S: survival rate, p: encounter rate, Dev: Deviance, np: number of identifiable parameters, AICc: Akaike value. Models which expect age effect on survival are indicated with a(1,2); t: time effect; *: interaction between age and survival; +: no interaction between age and time; .: constant value.*

model	S	p	Dev	np	AICc
m4	a(1,2)	t	1060.9373	17	1094.94
m3	a(1,2)+t	t	1038.8053	31	1100.81
m1	a(1,2)*t	t	1032.9396	42	1116.94
m2	a(1,2)*t	.	1064.7231	30	1124.72
m6	.	t	1142.0576	16	1174.06
m5	t	t	1129.9217	29	1187.92

3.5 Dispersal

3.5.1 Natal dispersal

Natal dispersal was assessed based on the live encounters of birds, which were ringed as pulli, at the age of at least 2 calendar years. Their observation distances were calculated. I separated adult birds and immatures (2 and 3 cy) in my study (fig. 11). Most of the resightings were made within 50 km from the natal place, and the distances tend to be bigger in immatures than adults, or at least more immatures were observed in big distances than adult birds. It is proven that at least some of the Black Storks return to their natal place as immatures (Kalocsa & Tamás 2002c, 2004a). Oversummering flocks are regularly observed in Europe.

As most of the observations were carried out at feeding places, and only a fewer number of birds were proven to be breeding (seen on nest) in the year of observation, I separated immatures (2 age groups), adults and proven breeding birds in calculating mean distances (Table 10). Mean dispersal distances are biggest in 2 cy immatures, while lowest in already breeding adults.

Table 10. Averages and standard deviations of distances of observations from the place of origin, grouped by age.

	min (km)	max (km)	mean (km)	SD	n
2 cy	4	1153	280	±386	54
3 cy	2	1246	271	±336	44
adults (excl. proven breeders)	2	2040	154	±269	74
proven nesting	0	421	140	±196	67

Out of the Black Storks colour-ringed in Hungary, the biggest distance of proven breeding was 165 km (SW) from the natal place. Only one bird is proven to breed outside of the country, in Croatia, but only 68 km (S) from its place of origin. From Poland, one female in 7 cy was observed in 2010 on a nest in northern Hungary (420 km SE), and one bird in 5 cy with a family in 2009 (189 km NE) from their natal places (Dolata 2010). From the Czech Republic, 26 colour-ringed Black Storks were identified on nests, and further 6 in breeding season in breeding range (Pojer 2009). In the Czech Repubic, in 34 % of the known cases, Black Storks were nesting up to 30 km from their natal places, 56 % within 60 km, and only 4 birds moved very far, around 400 km (2 NW to Germany, 1 SW to Germany and 1 SW to Austria). From Estonia, only 4 Black Storks were identified as adults in the breeding range during breeding season, and 1 of them was proven to have been nesting, 138 km SE from its natal place, at 8 cy. All the four birds were seen south of the place of origin, SEE, SE, SW and SWW respectively. From Serbia, 2 individuals are suspected to breed in Hungary, and 1 is proven. Their direction is N. There are two documented cases when a Black Stork was breeding in the same nest in which it hatched, both happened in Latvia (Strazds pers.comm).

The directions of dispersal are determined also for immatures and adults separately (fig. 12). Proven breeding tends to be closer to the natal place. There are slightly more resightings of breeding birds to western direction from the places of origin, but this number is very low as of yet, and can be much biased because of the inequalities in volunteer activity in the different regions of Europe.

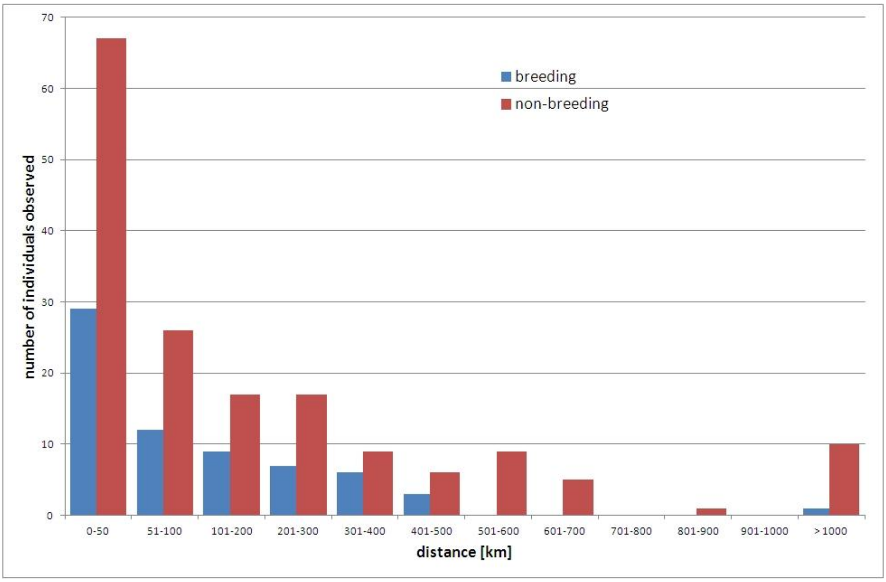

Figure 11. Distances of observation of breeding and non-breeding Black Storks from their natal place in breeding season, n=234.

In 3 cases adults in nests with colour rings were identified on webcamera images (76M in Estonia, 0AMT in Latvia and 56C in Hungary), but this happened by accident only as the number of nests with camera observation is still very low.

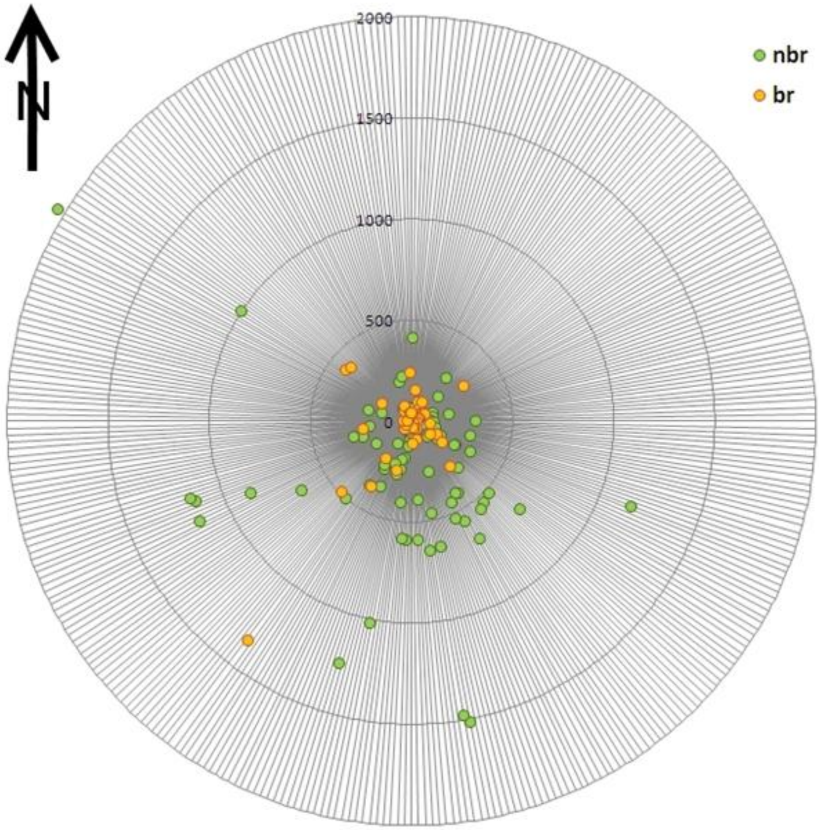

Figure 12. Orientation of breeding and non-breeding Black Storks from observations during the breeding season, n=234.

In recoveries, the youngest individual proven to have bred was 4cy. There was only one exception of this, in the Czech Republic where a bird in its 3 cy was observed breeding (Pojer 2009).

In order to examine whether the place of origin itself plays a role in dispersal distances or not, dispersal distances are also separated as function of the latitude of origin (fig. 13). Distances show a weak but susceptible correlation with the latitude of origin in case of non-breeding individuals, which may suggest that birds while immatures originating from more north tend to move farther away, or not to go back north in their first 2 or 3 years, but for breeding birds no such difference can be seen.

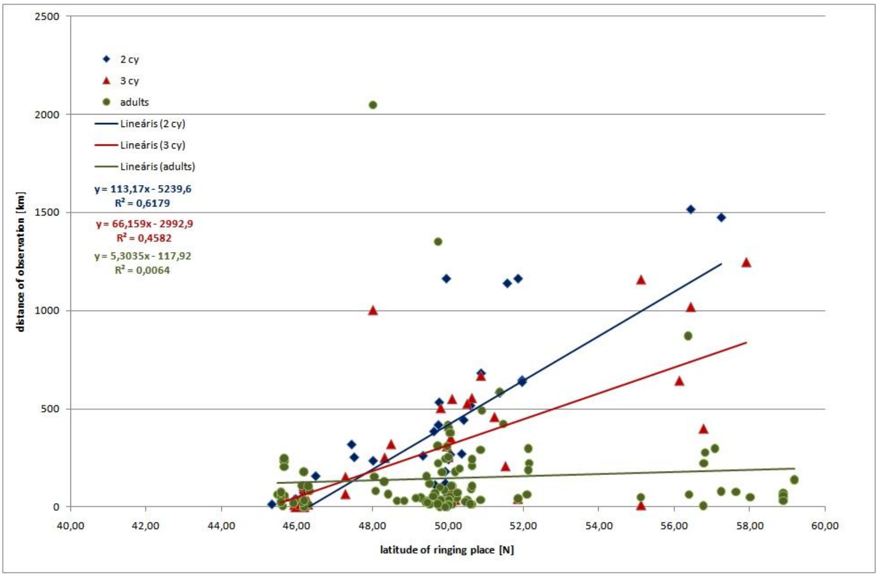

Figure 13. Distances of Black Stork observations from their natal place, as a function of the latitude of the natal place (n=234)

3.5.2 Breeding dispersal

Data of breeding birds that can be individually recognized (are marked) are very scarce as of yet. However, present knowledge indicates an extraordinary fidelity to breeding places. Adults do return to the same nest to breed in consecutive years, unless the nest becomes unsuitable for breeding (falls down). In cases like that, they are likely to breed as close to the fallen nest as possible, i.e. the nearest suitable nest tree (even in the same tree on another branch, pers. obs.).

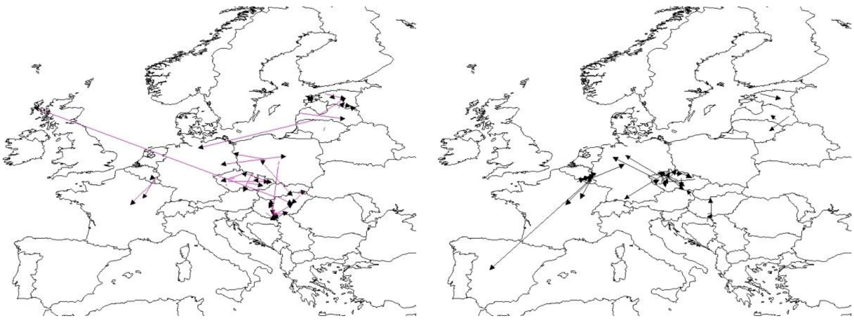

Figure 14: Observations of Black Storks in the breeding range. Left: adults (n=74), Right: proven breeders (n=67)

3.6 The migration of the Black Stork

3.6.1 Results of migration counts

First I give the summary of the regular migration counts, showing the changes in the numbers of migrating Black Storks at each place, and thus the importance of each migration route from the viewpoint of the species. I try to determine the migration divides.

From fig. 15, it can be clearly seen that the number of Black Storks passing through the Pyrenees has increased from nearly zero to around a hundred until the second half of the 1980s. In recent years, the number of Black Storks crossing in Autumn migration at the Straits of Gibraltar seems to be further increasing. In the second half of the 1990s, already an average of 1200 birds was counted mainly by the participants of the MIGRES Project near Gibraltar (Parkes 2004).

3.6.1.1 The Pyrenees and the Straits of Gibraltar (France – Spain)

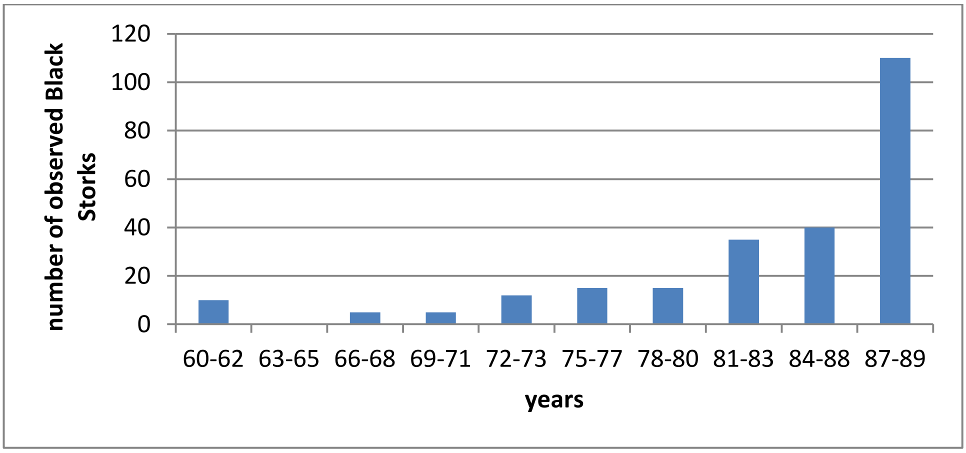

Figure 15. The seasonal numbers of observed Black Storks at the Pyrenees, autumn migration 1960-1989 (after Madrono et al 1992).

This, according to different sources is due to the re-colonisation of the long abandonned breeding territories like France, Belgium and Luxembourg. The Black Storks that re-colonised western Europe from the early 1990s, are, according to the commonly accepted theory, the overspill from the exploding stork populations in the Baltic countries and the Czech Republic. It is interesting though, that instead of making for Turkey, they instantly rediscovered what are presumed to be the old migration routes of the abandoned, western European stork colonies. They flew south-west across France and Spain to the short sea- crossing at Gibraltar, then down to western Africa[22].

[22] "There was no one to teach them or show them the way. How this happened remains a great and unfathomable mystery," (Patrick Lorge, of Cigognes Sans Frontieres and a Luxembourg bird protection group)

3.6.1.2 The Straits of Messina (Italy)

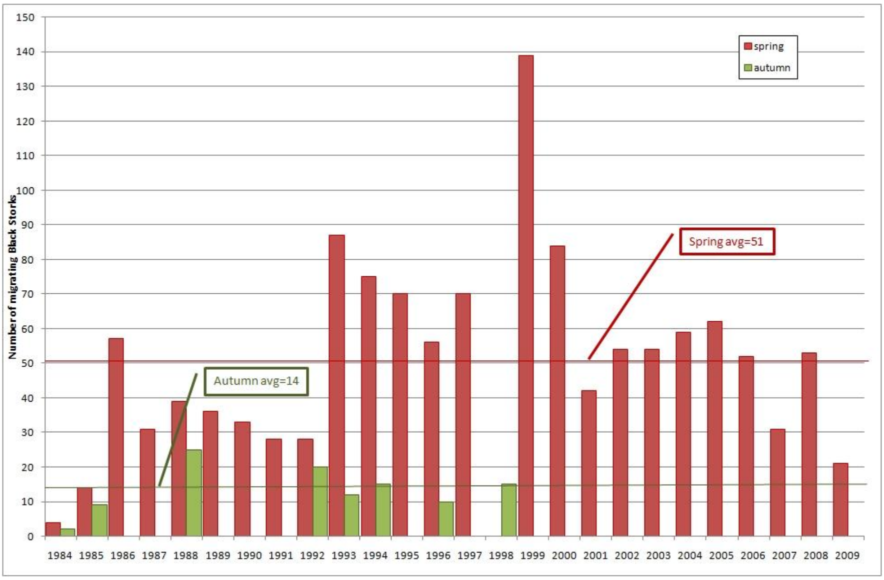

Figure 16. Number of migrating Black Storks observed at the straits of Messina, 1984-2009 (after Corso et al 1999).

Some sources in recent literature (Janssen et al. 2004) mention the „mediterranean route" as a real alternative of Black Stork migration. The phenomenon may be worth of investigations in the future, in order to find out more about the origin and the age distribution of the birds crossig here. Up till now, a few recoveries are known: a 1st cy bird, satellite tracked from the Czech Republic is proven to be shot in Italy, as well as a colour-ringed 1st year Hungarian individual reached the same tragic fate here. However, the number of birds observed here during regular counts still remains on the average less than 0.1 percent of the estimated European Black Stork population, and does not constitute a significant group.

3.6.1.3 The Macin Mountains (Romania)

Full season autumn migration count of soaring birds was carried out in Dobrogea, Romania, between 2002 and 2007, organized by "Milvus Group" Association. The location of the observation point was established in the Măcin Mountains (346 m). The study mostly targeted raptor migration, but, a certain number of Black Storks were also regularly observed, heading south – presumably towards the Bosporus Straights. The number of Black Storks observed in Măcin the respective years was as follows:

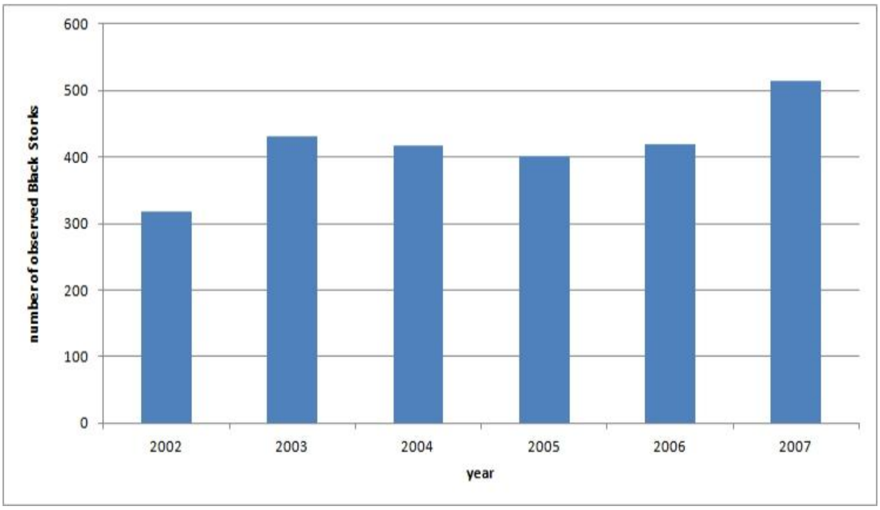

Figure 17. The number of Black Storks observed in Măcin during autumn migration counts, 2002-2007 (after Zeitz et al 2008).

3.6.1.4 The Bosporus, the Dardanelles and the Belen Pass (Turkey)

Ring returns and telemetry studies have shown that most Eastern European Black Storks cross the Bosphorus Strait during migration. Unfortunately there has been no continuous long-term monitoring.

Historical data were only available from scarce articles and the notebooks of ornithologist tourists. The Istanbul Birdwatching Society (IKGT) started to collect these. Full (or nearly full) season counts for Black Storks were available from 1966, 1969, 1971, 1973, 1975, 1978, 1980, 1981 and 1988 only. These are given in fig. 18.

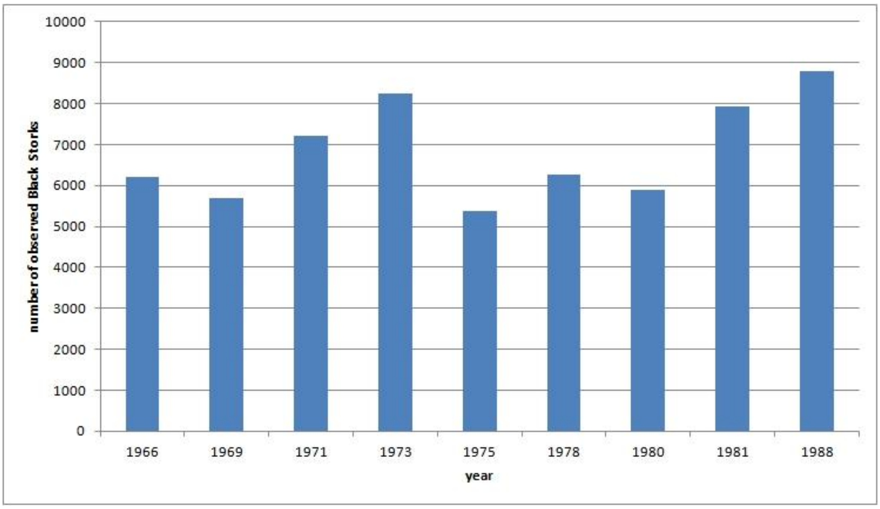

Figure 18: Number of Black Storks observed during migration counts at the Bosporus Straights, historical data.

It was discovered that in the spring movements are unpredicTable and wide ranging, but in the autumn they take a much more predicTable route. This is why mostly the autumn data are reliable for the estimation of the proportion of the European Black Stork population crossing here.

From all available data an average of 7184 individual Black Storks crossed this site annually with a standard deviation of 1201 (coefficient of variation=17%). The lowest count occurred in 1975 (n=5389) and the highest in 1988 (n=8792). The most recent complete count was in 2006 and totaled 8,436. These numbers suggest that populations have remained stable over the last 40 years (1966-2006 n=11) and are currently near a peak.

In the last 50 years (1956-2007, n=30) peak autumn passage dates have all occurred during the last two weeks of September, but migration starting dates have shifted approximately 10 days later from mid-August to late August.

At the Dardanelle's Strait observations from peak times of migration revealed little Black Stork movement. At the southern part of Turkey, the famous Belen Pass more than 5000 individuals are counted on the average in autumn, but totals are regularly less than the totals at Bosporus, meaning that not all birds cross here. Unknown in spring (Simit 2008).

Other literature mostly corresponds with the above-mentioned most recent publication, as they report that active migration of the Black Stork is rarely observed in South-Eastern Anatolia. The species is much more common in the western 2/3 of Turkey, mainly between March and early June, but with the highest numbers from early August to early November, the bulk occurring between the beginning of September and early October. They refer to a highest count in Istanbul in 1973 with 8318 individuals passing in the autumn season (this is lower than 8792 reported by Simit (2008) for 1988, but somewhat higher than 8245 which Simit (2008) reports for the same season). Peak days are reported on 25 Sep 1973 with 2556 Black Storks passing; 18 Sep 1978 with 5333 and 20 Sep 1995 with 2588 birds during a day (Kirwan et al 2008).

It’s remarkable that the peak days at the Batumi site (Caucasus, detailed in the next chapter) also fall around the 20th September, and this coincides with van den Bossche reporting the most of the Black Storks passing through Israel not more than a week later (van den Bossche 2004).

3.6.1.5 The Caucasus (Georgia)

Counts are carried out in an organized way since 2008. The number of observed migrating raptors is incredibly high, while, Black Storks use this passage in surprisingly low numbers, as the counts show in the graphs below (fig.19) (pers. comm Verhelst).

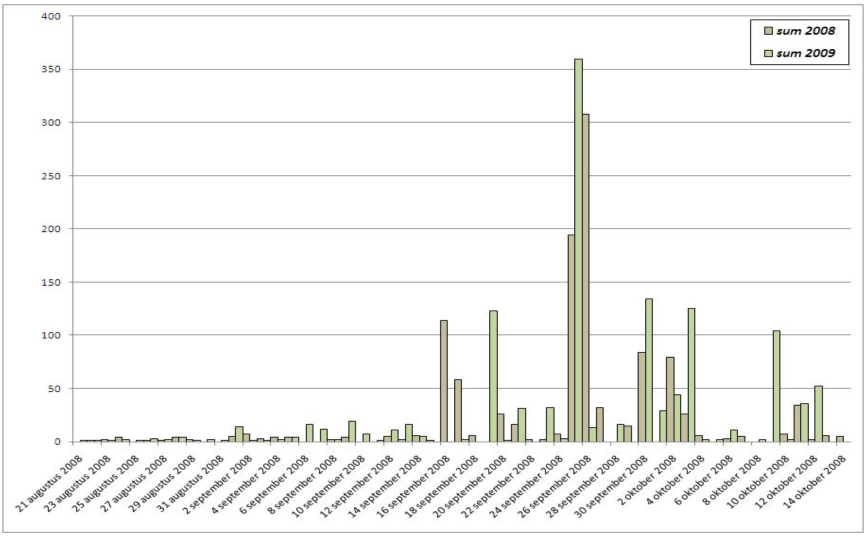

Figure 19. Dynamics of Black Stork migration over the West Caucasus, 2008-2009 (data: Batumi Raptor Count)

3.6.1.6 The Jordan Valley (Israel)

The Bet She'an Valley is the main flyway of Black Storks on the Eastern route with up to 17000 Black Storks passing in autumn and at least 8000 in spring. A large proportion of the migrants are stopping to feed and rest. The concentration of fishponds creates a unique situation for wintering Black Storks (van den Bossche 2004, Bahat 2008).

From the beginning of August to late October, 14097 Black Storks were counted in 1993, and 16844 in 1995. The route through Israel stretches parallelly with the Mediterranean shores, 57-65 km East of the Sea, along the Jordan River valley (van den Bossche 1996).

On spring migration, according to present knowledge, the species uses no stopovers. Black Storks usually migrate in loose flocks, but (particularly in spring) lonely individuals can often be as well seen (pers. obs.). During migration and stopovers the constitution and size of flocks changes frequently (pers. obs.).

3.6.2 Stopover places

In order to examine the future prospects of Black Storks to have available feeding grounds in the breeding season and during migration, I determined the most important stopover areas based on the satellite telemetry GIS (fig. 20). I supplemented this information with personal observation, and, in the case when this was impossible during my period of study, with personal communication of observers who had experience (van den Bossche, Rohde pers. comm.).

The Black Stork always choses the feeding places which are (1) exactly on the migration route, no detour is made (2) shallow enough to wade well (3) where the abundance of fish is high (Bahat 2008). It is observed that they will eat up the amount of fish easily accessible in the shortest possible time, in Israel even flocks of Black Storks feeding by night is reported (Hovel pers. comm).

I introduced the term „Important Stopover Area" (ISA). I found three typical and characteristic ISAs along the eastern flyway, while until recently, only Israel was considered widely as ISA for the Black Stork. I studied the Pannonian Central Danube Floodplains (CDF) and Central Anatolian lakes personally. I tried to assess their importance, and their role in the timing of migration. I describe these three major ISA-s along the Eastern Migration route in „Wetland Factsheets" (Tables 10, 11 and 12).

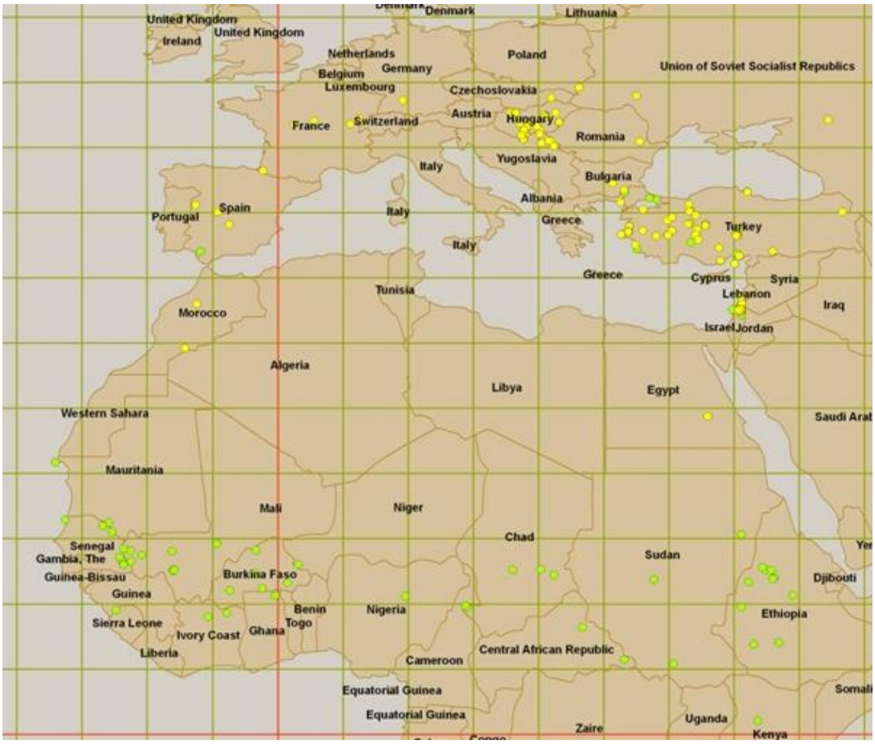

Figure 20. The identified stopover sites (yellow) and wintering grounds (green) of European Black Storks.

Colour ring recoveries and some satellite tagged birds (very few were tracked in consecutive seasons) prove that at least a part of birds do return to the stopover places used already before, if they are in suitable condition for feeding there. There are more colour ringed individuals identified several times at the same stopover area (van den Bossche, Rohde pers. comm, pers. obs.).

In case of the CDF Black Storks leave the area earlier, even in August in case floodplain feeding places are unavailable (e.g. waterlevel is too high), but large flocks stay until mid-October if suitable circumtances develop. I have no information though, how their further migration is influenced by the lack of this ISA. They might cross to Asia earlier (further research is to be invested in the question if there is a correlation between European stopover feeding place availability and migration peaks at the Bosphorus straits).

Table 10. Wetland factsheet – Pannonian Central Danube Floodplains (Annexes 6,7)

Question	Answer	Notes
water regime	natural	
wetland type	intermittent	
human influence	yes	river regulation
alternative food resource	yes	CDF fishponds, with limited accessibility
fish production	natural	
hydrological dependence	Danube catchment	Germany, Austria
maximum observed BS flock	400+	
estimated number of BS using	1000-3000	
direct threat	disturbance	
indirect threat	navigation, flood protection	„traditional" methods
conservation measure	yes	temporary and partial solution
area protection	yes	National Park, Ramsar, IBA, N2000
management plan	no	in preparation for 10+ years

Table 11. Wetland factsheet - Central Anatolian lakes (Annexes 8,9)

Question	Answer	Notes
water regime	natural	
wetland type	intermittent	
human influence	yes	amelioration in the catchment
alternative food resource	no	
fish production	natural	
hydrological dependence	local catchment	
maximum observed BS flock	400+	
estimated number of BS using	3-5000	
direct threat	disturbance	
indirect threat	changes to natural hyd. regime	diversion of runoff
conservation measure	no	
area protection	yes	IBA, Ramsar
management plan	no	

In Turkey, almost all the waterbodies are under great stress from pollution, water extraction, drainage or urban development. Irrigation schemes divert the fresh water feeding the salt lakes in Central Anatolia, and the salt steppe is being converted into cultivable land. The salinity is increasing in the salt marshes as the water Table is deepening. Some of the wetlands are protected (i.e. are Wildlife Reserves or Ramsar sites), but protection has not been sufficient to prevent the State Water Authority (DSI) in implementing water extraction development plans. So the principal threat to wetlands in Turkey is mismanagement, particularly through changes in the hydrology and over-consumption of groundwater resources (Kirwan et al. 2008).

I have no proof that Black Storks may change their migration route because of the unavailability or unsuitable condition of an ISA. It is interesting hovewer, that in some cases (years) many satellite tracked Black Storks flied over Israel without stopping for more than one night (van den Bossche pers. comm.).

Table 12. Wetland factsheet - Jordan valley fishponds (Annexes 10,11)

Question	Answer	Notes
water regime	artificial	
wetland type	intermittent	
human influence	yes	commercial fish production
alternative food resource	no	
fish production	artificial	
hydrological dependence	managed	as fish production requires
maximum observed BS flock	1500+	
estimated number of BS using	up to 15000	
direct threat	disturbance	protection against feeding birds
indirect threat	competition	
conservation measure	no	
area protection	no	
management plan	no	

In Israel, where water resources are scarce for the human population, there is a development plan under implementation in the Jordan River valley, which is famous for its fish production for a few decades. The program consists of phased aquaculture intensification in the Beit Shean Valley to improve efficiency of resource use and production activities. One part of the program is designed to optimize water conservation in the Beit Shean Valley by converting extensive aquaculture operations to intensive systems. The process of intensification will enable the growth and maintenance of productive potential for aquaculture in the Jordan River region, despite the substantial projected decline in the volume of water flowing in the Jordan River and extracted from it. The program is designed to meet the water needs of fish farmers under the assumption that yields will increase at an average rate of 10% per annum.

Fish farmers are already taking protection measures against birds, and numerous fish-eating migratory birds are trapped in nets or killed with shotguns including Pelicans, Spoonbills and Storks (Rohde, van den Bossche, Szabó pers. comm.).

4 Discussion

According to Fontaneto et al. (2006), Löhmus et al. (2005) and Treinys et al. (2008) alike, Black Storks prefer non-fragmented woodlands, and a rich hydrographic network. Canopy of mature woodlands in the area is not a precondition for breeding according to Sackl & Strazds (1997). Even if prevalent number of pairs breed in old stands, these can be considered as a fragments of once spacious native forests, now degraded, and interspaced by planted non-native trees. All the forest stands in the study area can be defined as semi-natural (Rebane et al. 1997). The trend of breeding on solitary mature trees of common oak and white poplar surrounded by young planted clones of poplar and willow is increasing. These mature trees have been left in the forest after logging, for the purpose of natural rejuvenation or, in case of oaks, wildboar feeding. Few nests are placed on planted allochthonous tree species, since on these trees, and within the monotonous stands they form, no suitable breeding niches for the Black Stork can be found (Tucakov et al. 2006).

The main features of forests which influence their value for wildlife are dominant tree species composition, continuity of forest woodland, and age and structure of stands (Ausden 2007). Old-growth forests often support a range of species that are rare or absent in more recently and more intensively managed forest. These include birds that require large-crowned trees for nesting (Newton 1998, Imbeau et al. 2000, Poulsen 2002), and the Black Stork is one of them. According to my findings, Black Storks in the study area preferred large, mature trees for nesting. Individual tree species differ in their suitability for nest sites (Hagvar et al. 1990). In the study area, the most frequently used nest trees were the largest and strongest in the stand in which they could be found.

Although the Black Stork is generally a solitary nester (Hancock et al. 1992, Sackl & Strazds 1997), there was an extraordinary breeding concentration in the Serbian part of the Pannonian Central Danube Floodplains, in Apatinski rit in 1996, when 7 pairs bred in old 153 ha large stand of white poplar and common oak (Puzović pers. comm.). This can indicate temporary very favourable conditions in smaller areas inside of the study area. In this case, all key habitat elements have attained optimal level. This occurs in the irregular years of optimally high water level. At the end of 1990's at least two such years occurred (Tucakov et al. 2006). The second possible reason for this concentration may lie in complex intraspecific relations (Lõhmus & Sellis 1996). The species might also be tending to breed in loose colonies if habitat conditions permit (Homonnay 1943).

The most severe threats the studied breeding area is facing with include loss of natural forests through inappropriate intensive forestry practice (Puzović & Grubač 2000, Tamás & Kalocsa 2005).

Table 13. Change in forest constitution in the study area. The area covered by native (natural) forest communities decreased with at least 62.3% during 150 years, while plantations of allochthonous species increased with at least 35.7%, not counting adventives. (data of the State Forestry Service used)

	1850 (%)	2000 (%)	% change
Quercus robur	30	13	-17
Populus nigra and P. alba	50	20.1	-29.9
Ulmus sp.	10	2	-8
Salix sp.	25	17.6	-7.4
Fraxinus sp.	N/A	9.4	N/A
native (natural) altogether			-62.3
Populus euramericana	0	24.6	+24.6
Juglans nigra	0	4.5	+4.5
Acer negundo	0	4.4	+4.4
Robinia pseudoacacia	0	2.2	+2.2
Fruit trees	10	N/A	N/A
plantation altogether			+35.7

Poplar plantations in the area are subject to very intensive management: poplar clones are fast growing and low-demanding regarding habitat conditions, while trunks are profitable. Intensive poplar breeding, coupled with the destruction of native softwood stands, wet meadows and character of riverside habitats, started in the area in the 1950's (Table 13). Recent plans foresee even more aggressive planting of poplars in the following years, particularly in the Serbian part of the study area (Marković & Orlović 2002). The remaining fragments of semi-natural stands, where white poplars and common oaks exist, bear from intensive management, too. Old trees of both species are preferable nesting places for this species, and their existence is a precondition for Black Stork nesting (Kalocsa & Tamás 1996b, Puzović et al. 1989).

Riparian areas, including recent floodplains, which are among the most productive and valuable natural systems on earth (Hunt 1985), have largely been degraded or otherwise altered by human activities. Riparian habitats are critical to wild bird populations, especially at places where agriculture is intense (Stauffer & Best 1980). Riverine forests are widespread all over Europe, but very small in extent, and restricted to narrow strips along major rivers, covering only about 20000 km^2, excluding Russia. Along practically all European rivers, most of alluvial forests have been converted to agricultural areas (Rebane et al. 1997). The total loss of alluvial wetlands in the Danube river basin is estimated to amount to 81% (DPRP 1999). In this type of wetlands vegetation develops over hundreds of years as a function of soil type, sedimentation, topography, hydrology and floods (Mitsch & Gosselink 1993).

Breeding density in the study area was higher than elsewhere in eastern Europe, where 1.3-1.8 pairs breed per 100 km^2, while density may reach 8.4 bp /100 km^2 in exceptional cases (Sackl & Strazds 1997). It is possible that breeding density is higher in alluvial forests in comparison to the mountain ones: for example in Austria densities are 0.2-1.7 pairs/100 km^2 (Sackl & Strazds 1997). However, the size of particular territories cannot be established according to the breeding density, since territories overlap on suitable foraging areas. Size of particular territories in floodplain forests can be 100-500 ha (Puzović et al. 1989), but also 50-150 km^2 (Profus 1994). Having in mind that the size of breeding territories predominantly depends on feeding conditions (Puzović et al. 1989), the high density of feeding niches in the floodplain of the Danube can be an evident reason of the exceptionally high density of the population.

The ecological integrity of river ecosystems depends on their natural dynamic character (Poff et al.1997). Because they are linked to other ecosystems through hydrologic connections, the cascading effects of habitat alteration on the whole watershed is particularly detrimental to floodplain wetland ecosystems (Faulkner 1994).

According to different published findings, the Black Stork is clearly a fish-eating species. It takes other kinds of prey, mainly amphibians, reptiles and small mammals, if fish are not available. This can be clearly seen from the present study, as the primary food during the breeding season, as well as migration, is evidently fish. The 15 most frequently reported prey of the Black Stork according to Janssen et al. (2004) are *Lampetra planeri, Salmo trutta, Esox lucius, Alburnus alburnus, Cyprinus carpio, Carassius carassius, Gobio gobio, Leuciscus cephalus, Rutilus rutilus, Tinca tinca, Misgurnus fossilis, Anguilla anguilla, Lota lota, Perca fluviatilis, Cottus gobio.* This is in coincidence with my findings.

It is visible that the dominant fish species in the diet of the Black Stork depends mainly on the habitat. The preferred feeding places of the Black Storks can be basically grouped into 3 hydrological types. In my study area the most characteristic feeding places are former river branches and oxbows in the floodplain, the water regime of which is intermittent. In the Dnieper meadows, in the Kijev region of Ukraine it is also documented that Black Storks foraged in little lakes and puddles that remained after the retraction of the flood, where the concentration of water animals was seen. They caught their prey solely from the water, wading in water to depth of 10-20 cm (Grischenko 1995). In hills, small creeks predominate where the birds catch their prey wading in the shallow water often for long kilometers. There are relatively smaller and/or less dense populations using this strategy of foraging e.g. in Belgium (Mahieu & Jadoul 2003) and in Greece (pers. comm. Kakalis).

Large congregations of Black Storks can occur on artificial fishponds if conditions are favourable. These depend on human behaviour, which is a matter of attitude and flexibility in management. In the last decades hundreds of Black Storks use the fishponds of the Danube river basin as stopover sites and staging areas, especially in dry years, when floodplain wetlands are unavailable during migration. There are severe problems coming from fishpond management (examples like this are not rare worldwide; the most well-known is the Jordan valley in Israel). In case the management of these fishponds do not allow for draining and harvesting in the time of Black Stork migration, 80% of the European Black Stork population can be threatened because of the loss of possibility to stop to feed during migration.

Wetland status and other hydro-meteorological factors also play an important role in the reproductive success of the species in the study area. I found that in correspondence with my preliminary suppositions, the number of young significantly depends on, and has a negative correlation with, the amount of precipitation in May and June and the length of the longest rainy period during the breeding season. The mean temperature in May and June are both positively correlated with breeding success. The results of the newest published climate modeling for the Carpathian Basin suggest that the significant temperature increase expected in this region may considerably exceed the global warming rate. The climate of this region is expected to become wetter in winter and drier in the other seasons (Pieczka et al. 2010), means if this comes true, the factor having the highest negative impact on Black Stork nestling success - summer rainfall - will change for the better with time. But as for the investigated period, during the relatively short 15 years, both summer rainfall and the length of rainy periods are increasing, which, until true, is a drawback for the Black Stork population – and the same holds for the average of the daily mean temperatures for May and June, as for my study period these seem to decrease significantly. Of course, the trends for a relatively short period of 15 years can be very different from the long-term tendencies.

According to my results, the number of Black Stork young is positively correlated to the mean spring waterlevel, meaning a higher possibility of fish to have a good spawning season, thus a higher abundance of the prey available for the species will positively influence the number of raised young. A higher effort of adults when they are forced to hunt outside the floodplain, depending on summer waterlevels, may hinder their abilities to properly feed their young. Although this is also supported by the model, the importance of this factor is not as high as the other ones.

Examining the time series of spring and summer waterlevels, it can be seen that while spring means are decreasing, summer means are slightly increasing in the investigated 15 years. If both of these trends prove to be true, that would be disadvantageous for the breeding of fish and the feeding possibilities of Black Storks alike. However, investigations of longer time series of waterlevels indicate a serious overall decrease of flow levels and inundation frequencies and durabilities not only in spring, for which river regulation for navigation and riverbed dredging for flood safety can be accounted (Kalocsa & Zsuffa 1998, Tamás & Kalocsa 2005, Goda et al. 2007).

Because of river training works and riverbed stabilization ecologically negative processes as riverbed erosion took place. This problem is increased by riverbed dredging on the reach near and upstream the area, and bed-load sediment transport from distant upstream is prevented by hydropower dams, that would cause a negative sediment balance itself. The main reasons for dredging are the maintaining of the waterway and river training. Natural bend development is prevented, so new branches do not develop any more. Because of sedimentation of the floodplain the existing dead branches and depressions are being filled up, and soon they will disappear. The average difference of the waterlevel of the Danube and the elevation of the floodplain is increasing with time. That's how the inundation frequency and the duration of inundation periods decrease (Tamás & Kalocsa 2005).

Biologically important parameters that change following channel activities include not only waterlevels, but water temperature, turbidity, flow velocity, hydrologic regime, a decrease or change in vegetation, changes in storage of organic matter and sediment, and changes in the size and stability of channel substrate (Hahn 1982). Brice (1981) indicates that effects on fish can be immediately apparent following channelization activities even though some of the morphological changes may take some time to adjust[23]. The effects depend upon the type of work done, the intensity and extent of the work and the extent of morphological change (Brookes 1988).

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23 Ecological issues in floodplains and riparian corridors. White Paper, Washington 2001.

The major habitat requirements of fish are barrier-free migration, suitable substrate, water quality and habitat connectivity for spawning, incubation and rearing, food availability, and shelter from extreme flows and predators (Brookes 1988). To the extent that the removal of in-stream and streambank vegetation also reduces shading, water temperatures can be expected to increase. Changes in temperature can alter the rate of egg development, growth rates and rearing success, species competition, and community composition (Beschta et al. 1987).

As in the study area the long-term trend of water levels is negative, this forecasts an increasingly lower spawning success of fish, which warns us of the possibility of a serious decrease of the primary food base of the stork. Even on highly regulated river reaches, it is proven that fish communities retain the need and the ability to utilise floodplain habitats when they become available (Peirson et al. 2008). On the examined reach of the Danube, because of the current practices of regulation, lateral connectivity is decreasing. In the past few decades, the number of fish species using these habitats decreased from 22 to 16, litophilic breeders have disappeared and fish biomass has also decreased significantly (Guti 2005). However, natural variability in fish populations makes it very difficult to separate changes in population that are natural variability and changes that are due to a specific channelization activity. (Brookes 1988). One of the biggest gaps in the literature is information that directly relates habitat changes to fish productivity (Brookes 1988). For the Black Stork, the potential future unavailability of its primary food source is of extraordinary concern. As fish serve as a food resource for all species of piscivorous birds and animals this is alarming, and also indicates an urgent need for the revision of river and floodplain wetland management and restoration strategies, as well as calls for a revision of the management policies of possible alternative food resources, such as fishponds.

Another very important thing in relation to feeding places in Europe, that oversummering flocks of Black Storks can regularly be observed in suitable feeding habitats in the breeding range, as well as immatures often also visit Important Stopover Areas on migration.

It is and interesting fact that except for the Carpathian basin, no occurence of oversummering immature flocks were recorded to date (pers. comm. van den Bossche, Strazds, Sellis, Pojer, Dolata). In the Carpathian basin however, this is not a rare case, indeed a regular phenomenon, proven by various ring readings in different years and places throughout Hungary (mainly Danube and Tisza river valley), northern Croatia and Serbia (pers. obs). These observations are relatively high in number, thanks to the activities of the international Black Stork colour ringing scheme.

The longevity of the Black Storks can also be estimated based on colour ringing activities: the age distribution in live encounters. According to this, more than 20% reaches adult age (3cy) and may start breeding, approx. 10% may live longer than 10 years, and some may reach more than 20 (approx. 5%). In literature (Janssen et al. 2004) the oldest ringed recovery in nature was 18cy, but in captivity a few individuals lived as long as 30 and 36 cy. This age (36) may be reached by 1.44% of the population in wild according to the survival rates conducted from recoveries.

The age distribution, the longevity estimates, the recovery rates and the survival of ringed individuals suggest that the population from which the ringing took place must be at least sTable or even increasing. However, this is not a strong argument and more effort needs to be invested in order to support this result. This was the first time a survival estimate was made for the species, so a possibility of comparison was not given.

The relatively high encounter rate is a result of the using of colour rings which can be easily identified, however the differences between encounter rates between years could suggest (1) the differences in efforts in order to identify ringed individuals; (2) the changes in conditions at feeding places and stopover roosts. The significant difference found between 1 cy and older birds can be caused by a real difference in survival, however higher permanent emigration of young birds might also have a role in it.

Comparing the results with the other European breeding stork, the White Stork, we can conclude that both species are relatively long-lived, but for the White Stork even 34 and 39 years in wild are reported[24]. We have to admit that the ringing of White Storks has traditionally been intense and there are much larger numbers of White Storks ringed and identified yearly, so the difference in the age of recovered birds does not essentially mean a real difference in the lifespan. We see that survival patterns are similar, despite the fact that habitat types used by the two species can be very different during the breeding season, as well as on migration and during wintering. Similarities in low survival of young might be due to similar main threatening factors - or causes of death - for the two species; for example, electrocution by and collision with power lines are reported as very serious for both species, especially in first-year birds (Schaub & Pradel 2004).

The annual survival rate of White Stork juveniles and adults was comparable both in Switzerland (Schaub & Pradel 2004) and in other countries, but in White Stork differences in survival rates were observed both within western populations and between western and eastern populations (Kanyamibwa et al. 1990), which could also hold for the Black Stork, but our data are insufficient to look at this. In White Stork, an effect of age was only noted as significant in the Alsacian population (Kanyamibwa et al. 1990). For the analysed Black Stork dataset, age effect turned out to be pre-eminent. It is a task for future research to confirm differences within and between populations, if any, for this species.

All the above results indicate a compelling need to intensify the colour ringing program and ring reading activities, and so do my results in relation to dispersal, which were also made possible thanks to the growing number of colour ring readings all over Europe.

Models for the evolution of the dispersal rate are based on a general trade-off between the benefits and costs of staying or moving (e.g. Levin et al.

[24] EURING Longevity List

1984, Johst & Brandl 1997, Leimar & Norberg 1997, Travis & Dytham 1998). Many of the factors affecting these costs and benefits involve consideration of the size, spacing, quality and temporal variability of particular habitats, the elements of modern landscapes which have been changed by recent human activities. Therefore, we might expect to see the differential survival of species which are characterized by different rates of dispersal. Habitat specialists were declining at a much higher rate than generalists, a sign that habitat quality is decreasing globally. There was evidence that natal dispersal was a predictor of recent trends, with species with high natal dispersal experiencing smaller population declines than species with low natal dispersal. It is expected if natal dispersal is higher, the ability to shift spatially when facing changes in habitat is larger (Jiguet et al. 2007). Identifying decline-promoting factors allow us to infer mechanisms responsible for observed declines in wild bird populations, and by doing so allow for a good approach to conservation planning, as dispersal can be in direct connection with habitat quality (Paradis et al. 2008), that may mean an adaptive strategy to avoid unfavourable conditions at the site of origin (Altwegg et al. 2000).

In Black Stork, there are only a few birds with observations in consecutive years up till now. Out of these, there is only one bird which was observed three times in consecutive years, considerably far from its natal place and the previous observation places as well (Hungarian 50P9). This bird, coming from the Börzsöny hills where it was ringed in nest as pullus, was observed as 2 cy in Biharugra, Hungary, 3 cy 996 km NW in the Netherlands, and the same bird later, as 4 cy, already in adult age, in the United Kingdom (2024 km, NW), which is indeed an irregularity and cannot be explained according to my present knowledge. Although no proof of breeding there was collected, this might be a sign of expansion of the range further north and west, in case it will be supported with more data in future. All the other consecutively observed individuals were returning to practically the same area (less than 20 km) where they were already observed before. Yet there are no evident tendencies of a flux from east to west, from presumed poorer quality habitats to new ones, as was previously suggested e.g. by Strazds (pers. comm.).

In different long distance migrant bird species it is shown that dispersal distances are relatively big, as well that natal dispersal distances are bigger than breeding dispersal (e.g. Paradis et al. 2008). The dispersal analysis of supposed and proven breeding adult Black Storks (1) did not show big distances (2) show not very much uniform orientation. In case the nesting place or breeding area of a specific adult was known, a high fidelity to that was observed, as earlier in other studies (e.g. Clobert et al. 2001).

Apart from dispersal, migratory movements were also targeted in my study. I tried to identify and exactify migration routes, by summarizing and analysing all available published and unpublished information. The route of stork migration between Europe and Africa is defined by flight strategy. The Black Stork, as other big birds, uses thermal soaring. Due to the general absence of thermals above the sea, the storks circumvent the Mediterranean Sea via southern Spain, close to Gibraltar or via Turkey and Israel (Bobek et al. 2008).

The numbers of Black Storks using the different migration routes are the result of summarizing the averages of the recent years' migration counts carried out in the different locations. The population using the Western route through the Pyrenees and the Straits of Gibraltar is increasing during the past 20 years (probably thanks to the re-colonization of these countries by the species), however it is still only around ten percent of the estimated European Black Stork population.

The Mediterranean migration route is represented only with around 0,2% of the Black Storks in autumn passage, according to observations and recoveries mostly 1st year and immature birds, a significant number of which is not proven to survive (or proven not to survive).

Migrating Black Storks are in low numbers but regularly observed in Greek islands (pers. comm. Kakalis, Noidou). The number of these individuals totals 15-20 in autumn, according to observers. However, the targeted wintering grounds and the places of origin of these birds are still unknown; there was one case when a first calendar year Black Stork colour-ringed as pullus in Croatia was observed in Crete (pers. comm. Mikuska).

There supposed to be some regular Black Stork movement in Yemen towards Africa across the Red Sea as well, but numbers cannot be given at present knowledge, furthermore there is even no estimate about the origin of these individuals (pers. comm. Balázs).

The exact delimitation of Black Storks' migratory divides are not known (Bobek et al. 2008). But current knowledge shows no evidence of geographical coincidence between the European and Asian, the European and African, and the African and Asian populations. As there is no proof of overlaps in wintering grounds, and migration routes seem to be much different, I could assume these three geographical parts of the range are isolated.

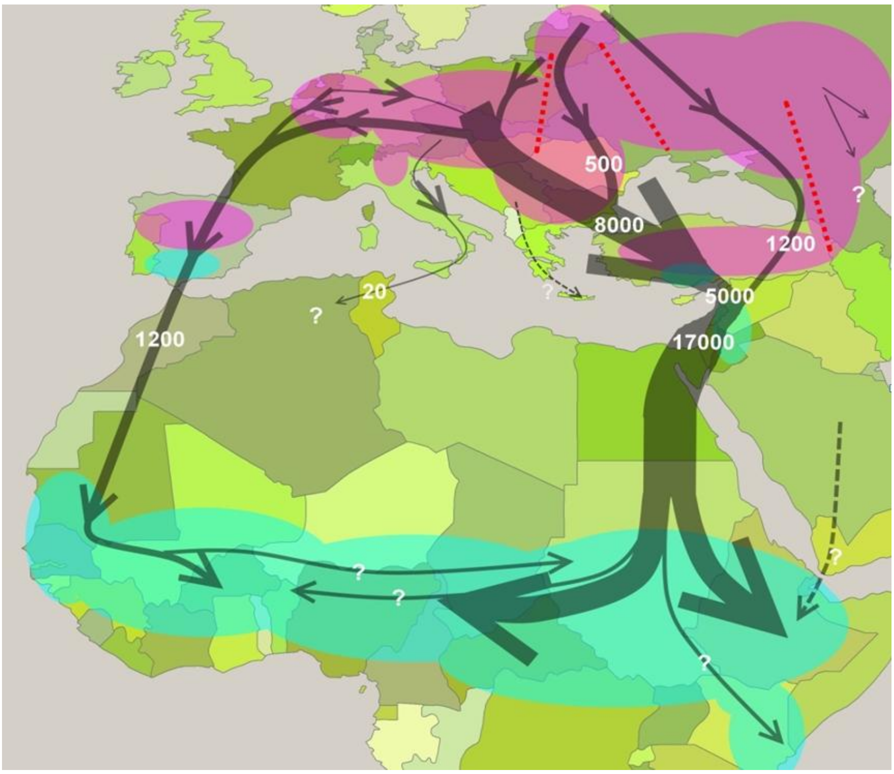

Figure 21. Main migratory routes of European Black Storks, based on literature, satellite tracking, colour ring recoveries and migration counts, re-drawn by the author

My data collection and the analyses of the ring recoveries and the satellite tracks revealed that the knowledge about the migration routes of European Black Storks needs to be reviewed (fig. 21). There are routes previously not described: from the direction of the Baltic countries along the eastern coasts of the Black Sea, crossing the Caucasus, and from the European part of Russia towards a south-eastern direction. The Baltic-Caucasus line was revealed by a satellite tagged Estonian Black Stork (FlyingOver Natura2000 project), and this fact is supported by the Batumi Raptor Count station, the numbers of which suggest that the importance of this route is about the same as of the route leading through the Pyrenees and the Straits of Gibraltar. The Russian route is suggested by three ring recoveries (EURING databank), and opens the question of a possible migration divide or transitional zone between the Baltic/north-east-European population and the Russian one. However, lack of any other data from this region prevents the author from stating that this is proven.

The previously supposed migratory divides prove to dissolve, to be incorrect or even non-existent; some of these are transitional zones indeed. There is a vast territory in Northern Europe and the Northern part of Central Europe (including the Czech Republic, Germany, Poland, Belgium and northern part of Hungary) from where both eastern and western migrants originate. This is proven by various CR-identifications and satellite tracked birds as well. There are overlaps between eastern and western migratory populations in Central Europe, furthermore in their wintering grounds it is expected to be proven soon. The easternmost wintering place of a „western” stork is more east then the westernmost „eastern” one – this also suggests the possibility of east-west or west-east loop migration.

4.1 Suggestions for conservation and management in the study area

Bearing in mind that the Black Stork is threatened locally particularly by the loss of breeding sites, human disturbance, and loss of wetland feeding areas, it can be used as a tool-species whose habitat requirements will serve for improvement of the management of its habitat (Kalocsa &Tamás 1996b, Stojanović 2001). The question, of course, is whether any of the ecosystem changes that we know are occurring can explain migrant bird declines to date or will lead to migrant (or other) bird population changes in the future in such a way that the key solution to bird conservation is found at a macro-geographic level rather than directly with regional and/or local habitat management (Faaborg et al. 2010).

In order to define a more sustainable forestry practice (Haffner et al. 1999), I suggest the adoption of the following guidelines and their implementation into legislation related to the protected areas, as well as into both conservation and forestry management plans as necessary Black Stork conservation measures.

There is a need to establish circular protection zones (recommended at least 400m radius), so-called „micro-reserves” around every nest, where all kinds of human presence should be excluded within the breeding season. All forestry activities should be prevented within 100 m radius around the nests[25] also outside the breeding season. Zielinsky (2006) investigated the role of forest micro-reserves in Poland. He arrived generally to the result that the number of sTable breeding pairs increased linearly with the establishment of micro-reserves. The usual conservation practice in many countries is that, after the nest of the Black Stork is created, buffer zones

[25] Suggestions of the Hungarian Raptor Protection Council; adopted in 2011

are established around the nest (post factum conservation activity). Another approach is to create forest reserves protecting old-growth stands without considering the actual presence or absence of the Black Stork (pre factum conservation activity).

A mosaic of old common oak and white poplar specimens should be left in every forest section where rejuvenation is planned. Remaining old and preserved forest fragments dominated by common oak and white poplars should be mapped and protected as a IUCN category I zone[26], in order to halt all interventions which could hazard them. No hybrid poplar plantations should be planned in protected areas of breeding grounds anymore, and previously planted hybrid poplar plantations should be carefully restored into autochtonous forest communities (Tucakov et al. 2006).

In the places where habitat degradation is already so prominent that the number of suitable nesting trees decreased to minimum, the application of artificial nests can be advised (Kalocsa & Tamás 2002d). We know that Black storks choose natural old forests for nesting, and their nest often falls down as the branch holding it dries out or rots away. Sometimes this happens in the breeding season. Furthermore there are former nesting sites where they cannot find suitable trees for nest building any more. There are some Black stork nests in highly disturbed forestry areas as well. In 1996 we started a trial in Gemenc to solve these problems by nest restoration and artificial nest/platform building (fig. 22).

During five years we have rebuilt 16 nests, out of which 15 were placed in place, or in the nearest possible vicinity of fallen nests. In conclusion we state that our method can successfully be used to keep the Black Storks nesting in disturbance-free places and to improve breeding success. Out of 16 nest reconstructions, Black Storks accepted the artificial platform and bred in it successfully in 9 cases.

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[26] http://www.iucn.org/about/work/programmes/pa/pa_products/wcpa_categories/

Figure 22. A successful method of artificial platform placement for the Black Stork

Identifying important feeding places and stopover refuelling sites of major importance, and determination of the hydrological constraints at these feeding places were also among my main goals. From the results the consequence is evident that restoration of wetlands is needed, in order to improve the hydrological regime of altered feeding habitats and establish possibility of movement and spawning for fish. As the wetlands which play an important role in food supply for the species are characteristically temporary or intermittent, an emphasis should be put on the preservation or restoration of dynamism in the hydrological regime, mainly in alluvial floodplains.

Probably the simplest, most direct and least expensive way to improve the integrity of stream systems affected by river regulation would be to halt current management strategies that are a partial cause of continued habitat degradation. Management strategies that encourage and allow natural adjustment and healing processes to evolve over time tend to succeed (Ebersole et al. 1997). In areas with numerous degraded waterways and limited resources, natural recovery may be the most efficient and pragmatic process toward the recovery of stream systems over wide geographic areas (Brookes 1996). However, natural healing processes can take upwards of 100 years in some extremely degraded systems (Bayley 1991; Kern 1998) and without some degree of human intervention might never return to a state close to previous conditions.

Allowing natural recovery to take place could permit 'surrogate' habitats to develop that provide increased habitat values compared to the current degraded conditions (Dennis et al. 1984). Therefore, natural recovery processes should be encouraged where feasible to maximize existing potential. However, in many cases the continued maintenance of channelized rivers through dredging, re-straightening, clearing and snagging, and bank protection maintenance has prevented the natural recovery of many channelized rivers worldwide[27].

Active restoration, rehabilitation or alternative management should be pursued where special human needs or opinions call for active management and only partial rehabilitation (Brookes 1996). This is the case of the Danube floodplains, where there is a controversy in that restoration of the whole floodplain habitat is impossible without the restoration of the river, but human uses, settlements and flood safety reasons prevent halting current river channel management practices.

While there are relatively few documented examples of successful or unsuccessful large-scale river restoration projects, there is a wide variety of published literature that acknowledges and calls for alternative paradigms in river restoration (Gore & Shields 1995, Johnson et al. 1995, Ebersole et al. 1997). Most of the scientific information that emphasizes the importance of lowland river and floodplain restoration has been derived from the analysis of the relatively few intact lowland river floodplains that still exist, e.g. in the lower floodplain of the Mississippi (Gore & Shields 1995).

Numerous large-scale floodplain restoration projects have been conducted in Europe, too. Morphologic habitat diversity of the sites improved after re-engineering the rivers. Future monitoring of these restoration sites will shed more light on riparian community response to the restoration works (Biggs 1998), e.g. the Danube floodplains in Austria (Tockner & Schiemer 1997).

[27] Ecological issues in floodplains and riparian corridors. White Paper, Washington 2001.

In my study area in Hungary, Danube floodplains have also undergone the first reconstruction projects. The formulation of restoration policies, goals and alternatives have been analyzed before project implementation (Marchand et al. 1995). The first initiative which targeted a possible wetland reconstruction in the area was started in 1992 in frame of the Dutch-Hungarian Co-operation on Water management: „Floodplain Rehabilitation Gemenc" - „The Stork Plan". It was immediately followed by the Vén-Duna - Nyéki holt-Duna wetland reconstruction feasibility study, which focused on the central and very characteristic part of the study area. Based on this, the implementation of the Vén-Duna - Cserta – Nyéki holt-Duna wetland reconstruction started in 1998 and was followed by a few years of monitoring. In 2001, a GEF World Bank sponsored project was submitted in order to decrease the nutrient load of the Danube, through the improvement of inundation frequency and durability of the floodplains in the study area (Tamás, Zellei et al. 2006). After the approval of the project, a new feasibility study was elaborated - now comprising the whole area - and the technical planning of the reconstruction works is currently underway.

During the management planning of the study area, the habitat needs of certain umbrella species, such as the Black Stork, were taken into account[28]. However, as the improvement of the floodplain hydrological regime was only possible by floodplain dredging and artificial water retention, this batch of interventions can be judged as solely symptomatic treatment, and the whole set of technical measures which are feasible under present socio-economic conditions is only postponing the problem for another few decades.

In the favour of breeding grounds and feeding places of birds, among them the Black Stork, many conservation actions have been undertaken recently, but – for practical reasons – most of them are limited in space and time (Doligez et al. 2004). The emerging discipline of Ecological Engineering provides some basic design principles for integrating societal and

[28] Tamás E.A. MS thesis, Budapest University of Technology, 2002.

ecological needs in patchwork-mosaic landscapes with complex land use (Bergen et al. 2001, Schulze 1996).

The efforts to design nature-management systems should be integrated in multidisciplinary approach, and geographically also, in the entire range of the Black Stork. It is known that linking habitat quality indicators to fitness or population consequences is needed, yet this task presents a major challenge (Faaborg et al. 2010). To answer it, large-scale, long-term population monitoring is needed, and it can only provide the basis for the assessment of the impact of conservation actions as well (Doligez et al. 2004). International attention, assistance and nature conservation funds must be concentrated to the planning and implementation of Black Stork-friendly conservation measures, having in mind the international importance of the Central and Eastern European breeding area and the eastern migratory route.

5 New scientific results

I have, together with my colleagues, determined the most important factors of nesting site selection of the Black Stork in a characteristic habitat based on the available data and information in recent years. The importance of intact mature deciduous forests as breeding areas for the species is proven to be extrordinary in Central Europe, where no alternative nest supports, i.e. cliffs can be found.

I have, together with my colleagues, studied the diet constitution of youngs continuously for 8 years in the same habitat complex for the first time in the research of the species, and, based on this, and supplemented with visual observations, the diet preference of the Black Stork, and the diet composition of youngs was determined. The species is proven to be clearly fish-eating, and, because of this, largely wetland-dependent.

I have found hydro-meteorological factors correlating with Black Stork breeding success, similar to those of other authors for other species. I found that – at least in the temperate areas of Europe, where weather impact in the past 15 years could have been very similar to that of the Carpathian Basin – the prospects of the Black Stork to avoid a serious population decline depend very much on rainfall, the changes in summer temperatures and the availability of suitable prey in the necessary abundance to feed their young. In my study area the long-term trend of waterlevels is negative, and this forecasts increasingly lower spawning success of fish, which warns us of the possibility of a serious decrease of the primary food base of the species. This indicates an urgent need for the revision of river and wetland management and restoration strategies, as well as calls for a revision of the management policies of possible alternative food resources: fishponds.

I have, first time for the Black Stork, given longevity estimates and survival modelling based on colour ringing and resightings. I found that survival is different between one year old and older individuals in Black Stork.

I have, with the help of volunteer observers and colleagues, proven for the first time that immatures of the Black Stork return to Europe. Several observations of oversumering 2 cy and 3 cy individuals support this, among them colour-ringed ones. Dispersal analysis shows no evident tendencies of a flux from East to West, as previously suggested.

I showed that previously presumed migratory divides are rather transitional zones, from which the individual choice of the direction of migration is unpredicTable to the present knowledge. My data collection and the analyses of the ring recoveries and the satellite tracks revealed that the knowledge about the migration routes of European Black Storks needs to be reviewed. There are routes previously not described: from the direction of the Baltic countries along the eastern coasts of the Black Sea, crossing the Caucasus, and from the European part of Russia towards a south-eastern direction. The previously supposed migratory divides prove to dissolve, to be incorrect or even non-existent; some of these are transitional zones indeed. The easternmost wintering place of a „western" stork is more east then the westernmost „eastern" one – this also suggests the possibility of east-west or west-east loop migration.

I dedicated a considerable part of my studies to wetlands, as Important Stopover Areas for the Black Storks. I grouped feeding habitats according to hydrological type, and assessed their importance. Based on satellite tracking results and field observations, I determined three Important Stopover Areas along the Eastern flyway, which, mostly because of human uses, are threatened by different factors. I identified main threats.

I have, based on 20 years' experience in the study area, given suggestions on the improvement of active species conservation and habitat management practices, mainly for Central European habitats and river floodplains as feeding places, in order to ensure the long term sustainability of Black Stork populations, especially at the breeding areas in Hungary and the most important wetlands along the Eastern flyway.

6 Summary

Problem definition

People have been altering the earth's surface for thousands of years (Drower 1954, Cole 1976, Brookes 1988). Land use and cover changes, caused by increasing human habitation coupled with resource consumption and extensive landscape modification, adversely impact natural ecosystems at multiple spatial scales (Faulkner 2004). Habitat loss has induced increased extinction risks for rare and highly specialised species, and particularly to migratory birds (Senra & Alés 1992), as migratory birds and species with specific habitat requirements are considered to be the most sensitive to anthropogenic disturbances (Croonquist & Brooks 1991).

Many publications can be found on the prominent effects of habitat loss on the populations of migratory birds, in their breeding grounds, wintering grounds and along migration routes alike (e.g. Batten et al. 1990, Collar & Stuart 1988, Bibby 1992, Newton 2004, 2006). In order to better understand the real status and conservation needs of these species, detailed knowledge on the breeding ecology, habitat and diet preference, dispersal and migration are needed. A single survey with habitat measurements can be used to predict occurrence according to habitat, but to investigate population processes, reproduction must be studied also as a priority (Bibby 1992). Problems may be diagnosed by studying breeding performance across time (Bibby 1992). In long-lived species, survival is also a key question, so it constitutes a preferential target for conservation measures (Lebreton 1978; Stearns 1992, Schaub et al. 2004). A complete understanding of population dynamics would require, among other factors, the analysis of dispersal (Pradel et al. 1997, Clobert et al. 2001).

In conservation biology, some of the most important challenges are to assess the status and risk factors of migratory species, as well as to foster decision making in habitat management and restoration for optimal conservation actions (Lebreton & Clobert 1991, Caswell 2001). A current trend is that more industrialized countries are likely to conserve their already impacted, remaining habitats, while nations with less industrialization are now experiencing accelerated losses, and may continue to do so for the next several decades (Brinson & Malvárez 2002). Restoration measures have to be planned and implemented before changes reach a point when restoration efforts become too costly or ecologically unattainable (Croonquist & Brooks 1991). By understanding the functional attributes of avian species we can determine what aspects of the habitat are important for effective management and restoration, to reverse the effects of cumulative impacts (Croonquist & Brooks 1991).

The above-mentioned factors certainly have an impact also on the Black Stork (Ciconia nigra Linnaeus 1758), though the significance of these effects on the populations of this particular species is not very well known.

According to the Sherry-Holmes model for understanding population limitation in migratory birds (Sherry & Holmes 1995), the four major periods when populations may be studied (breeding, wintering, and two migration periods) are distinguished.

This model suggests that migratory bird populations can be limited by conditions on either the breeding or wintering grounds, or by factors that occur while in transit between these. Populations of migratory birds are often considered to be limited in breeding or wintering areas (Newton 2004), but some might be highly influenced also during migration (Newton 2006). Breeding ground limitation can occur in the form of effects on survival rates of breeders or variations in nesting success that change population trajectories, with emphasis on the role of variation in habitat quality on the rates of survival and reproduction (Faaborg et al. 2010).

A characteristic influence can be attributed to stopover sites, e.g. in form of competition for food supplies, as birds can concentrate in places like this in great numbers, and food can become scarce (Newton 2006). Most of nonbreeding-season demographic studies have tended to focus on survival rates, as this is the most obvious demographic factor at this time of year (Faaborg et al. 2010). But conditions at stopover sites can influence, among other factors, refuelling rates and migration speeds, subsequent reproduction and survival, and through these, population trends as well

(Newton 2006). Particular aspects of this subject area have been reviewed, among others, by Moore & Simmons (1992), Moore et al. (1995), Drent et al (2003), as well by Jenni & Schaub (2003).

For the Black Stork in Eurasia, most of the effort of studies during the nonbreeding season was invested in Western Europe and the Western migratory route (Bobek et al. 2004, 2008, Chevallier et al. 2008, 2010a, 2010b, 2011, Jiguet et al. 2011), and this is a great inequality, as the vast majority of the European population is supposed to be Eastern migrant (Tamás, Kalocsa et al. 2006).

Goals of the study

In my work, I set the goal to summarize present knowledge on an Eastern migrant European population of the Black Stork, and investigate some of the factors for the breeding season and during migration. The biggest threats to the Black Stork are considered to be the decrease in availability and quality of nesting trees and feeding grounds, especially the various streams and water bodies of all kind in the entire range of the species (Tamás, Kalocsa et al. 2006). I would like to outline the dependence of the Black Stork during its breeding season and autumn migration on the status and availability of floodplains and other types of temporary wetlands along the flyway, in terms of reproductive success, and the timing and success of migration. I would like to stress the importance of some extraordinary wetlands along the Black Stork flyway, discover the threats affecting these, and give a suggestion on the substantiation of a Black Stork-friendly forest and wetland conservation strategy.

Results

In order to answer the above-mentioned questions, I summarized the achievements of the fieldwork and studies in which I actively participated in the past 15 years, in relation to the breeding ecology, habitat preference, diet and feeding places, longevity and survival, dispersal and migration of the species.

I have, together with my colleagues, determined the most important factors of nesting site selection of the Black Stork in a characteristic habitat based on the available data and information in recent years. The importance of intact mature deciduous forests as breeding areas for the species is proven to be extraordinary in Central Europe, where no alternative nest supports, i.e. cliffs can be found.

I have, together with my colleagues, studied the diet constitution of young continuously for 8 years in the same habitat complex for the first time in the research of the species, and, based on this, and supplemented with visual observations, the diet preference of the Black Stork, and the diet composition of young was determined. The species is proven to be clearly fish-eating, and, because of this, largely wetland-dependent.

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I have, based on 20 years' experience in the study area, given suggestions on the improvement of active species conservation and habitat management practices, mainly for Central European habitats and river floodplains as feeding places, in order to ensure the long term sustainability of Black Stork populations, especially at the breeding areas in Hungary and the most important wetlands along the Eastern flyway.

7 Összefoglaló

Problémafölvetés

Az ember évezredek óta módosítja a földfelszínt (Drower 1954, Cole 1976, Brookes 1988). Az ember által elfoglalt terület növekedése, az erőforrások fokozott használata és a tájkép átalakítása a területhasználat és a felszínborítás változásához vezetnek, így különféle térbeli skálákon tekintve káros hatással vannak a természetes ökológiai rendszerekre (Faulkner 2004). Az élőhelyek elvesztése megnövelte a ritka és erősen specialista fajok kihalásának veszélyeit, különösen a vonuló madarak esetében (Senra & Alés 1992), hiszen a vonuló madarak és a különleges élőhely-igényű fajok a legérzékenyebbek az emberi eredetű zavarásokra (Croonquist & Brooks 1991).

Az élőhelyek elvesztésének a vonuló madarak populációira gyakorolt hatásaival kapcsolatban számos publikáció látott már napvilágot a költőterületekre, a telelőterületekre és a vonulási útvonalakra vonatkozóan egyaránt (e.g. Batten et al. 1990, Collar & Stuart 1988, Bibby 1992, Newton 2004, 2006). Annak érdekében, hogy ezen fajok valós helyzetét és védelmi igényeit jobban megérthessük, részletes információkra van szükségünk a költésbiológia, a fészkelőhely- és a táplálékválasztás, a diszperzió, túlélés valamint a vonulás vonatkozásában (Bibby 1992, Lebreton 1978, Stearns 1992, Schaub et al. 2004, Pradel et al. 1997, Clobert et al. 2001)..

A természetvédelmi biológia egyik legjelentősebb kihívása a vonuló fajok helyzetének és az azokat veszélyeztető tényezőknek a föltárása, valamint az élőhelyek kezelésével és rekonstrukciójával kapcsolatos döntéshozatali folyamatok megalapozása az optimális természetvédelmi beavatkozások érdekében (Lebreton & Clobert 1991, Caswell 2001). Napjaink tendenciája, hogy a fejlettebb országok nagy hangsúlyt fektetnek a már erősen befolyásolt állapotú maradék élőhelyeik védelmére, miközben az elmaradottabb térségekben fölgyorsulnak az élőhelyvesztési folyamatok, és az elkövetkező évtizedekben ennek fokozódása várható (Brinson & Malvárez 2002). Az élőhely-rekonstrukciós tervezésnek és kivitelezésnek meg kell előznie azt a pontot, ahonnan már aránytalanul költséges vagy éppen ökológiai szempontból lehetetlen feladat lenne a káros folyamatokat visszafordítani (Croonquist & Brooks 1991). Ha megértjük a madárfajok funkcionális igényeit, akkor meg tudjuk határozni azt is, hogy az élőhelyek mely jellemzői fontosak a kezelés és a rekonstrukció szempontjából, és így lehetőségünk nyílik megfordítani a kedvezőtlen folyamatokat (Croonquist & Brooks 1991).

Az eddigiekben írtak kétségtelenül igazak a fekete gólya (*Ciconia nigra* Linnaeus 1758) esetében, bár a különböző tényezők fontosságát e faj populációira gyakorolt hatásaik tekintetében még kevéssé ismerjük.

A vonuló madarak populációs limitációjának megértéséhez kidolgozott Sherry-Holmes modell (Sherry & Holmes 1995) szerint megkülömböztetjük azt a négy fő periódust (költés, telelés és két vonulási időszak), melyekben a populációkat vizsgáljuk. E modell szerint a vonuló madarak populációinak limitáló tényezőit kereshetjük a költőterületeken vagy a telelőterületeken, de az ezek közötti útvonal mentén is. A vonuló madarak esetében a limitáló tényezőket gyakran kötik a költőterületekhez vagy a telelőterületekhez (Newton 2004), de igen jelentős hatások jelentkezhetnek a vonulás során is (Newton 2006). A költőterületen előforduló hatások nagy része jelentkezhet a költő állomány túlélése vagy a költési siker megváltozásában, melyek a populáción belüli arányok megváltozását okozzák. Ezek között ki kell hangsúlyozni az élőhely minőségi változásainak a túlélésre és a reprodukcióra gyakorolt hatásait (Faaborg et al. 2010).

Jelentős hatások érhetik a vonuló madarakat a megállóhelyeken, például a táplálék-kompetíció formájában – mivel az ilyen helyeken nagy számban koncentrálódhatnak a madarak és így a táplálékforrások szűkössé válhatnak (Newton 2006). A költési időszakon kívüli kutatások nagy része a túlélési rátákra koncentrál, mivel ez a legnyilvánvalóbb demográfiai jellemző az év ezen időszakában (Faaborg et al. 2010). De a megállóhelyeken uralkodó körülmények ezen kívül befolyásolhatják az energiatartalékok raktározásának és magának a vonulásnak a sebességét, a vonulást követő költés sikerességét és a későbbi túlélést is, és ezek által a populációs trendeket is (Newton 2006). Ennek a szakterületnek az áttekintését adja többek között Moore & Simmons (1992), Moore et al. (1995), Drent et al (2003), és Jenni & Schaub (2003).

A fekete gólya eurázsiai állományaira vonatkozóan a költési időszakon kívül végzett kutatások nagy része Nyugat-Európára és a nyugati vonulási útvonalra korlátozódott (Bobek et al. 2004, 2008, Chevallier et al. 2008, 2010a, 2010b, 2011, Jiguet et al. 2011), és ez meglehetősen egyenlőtlen, mivel az európai populáció túlnyomó többsége keleti vonulónak tekinthető (Tamás, Kalocsa et al. 2006).

A kutatás célja

Munkámban célul tűztem ki, hogy összefoglaljam a fekete gólya egy keleti vonulású európai populációjára vonatkozó jelenlegi ismereteket, és hogy megvizsgáljam a költési és vonulási időszakokban föllépő jelentősebb tényezőket. A fekete gólya szempontjából a feltételezett legjelentősebb veszélyeztető tényezők a fészkelésre alkalmas fák és táplálkozóhelyek mennyiségi és minőségi csökkenése, különös tekintettel a különböző víztestekre a faj teljes elterjedési területén (Tamás, Kalocsa et al. 2006). Célom volt, hogy leírjam a fekete gólyának a folyóárterek és egyéb időszakos vizes élőhelyek állapotától és rendelkezésre állásától való függését a költési időszakban és az őszi vonulás során, a költési siker és a vonulás időzítése valamint sikere szempontjából. Szeretném kiemelni a faj vonulási útvonala mentén néhány kitüntetett jelentőségű vizes élőhely fontosságát, fölfedni az ezeket veszélyeztető tényezőket, és javaslatot tenni egy fekete gólya-barát erdő- és vizes élőhely-védelmi stratégia alapjaira.

Eredmények

A fölvetett kérdések megválaszolása érdekében összefoglaltam a faj költésbiológiájára, élőhely-választására, táplálkozására és táplálkozóhelyeire, élettartamára és túlélésére, diszperziójára és vonulására vonatkozóan az aktív részvételemmel zajlott 15 évnyi terepmunka eredményeit. A fekete gólya élőhelyválasztásának legfontosabb jellemzői egy tipikusnak tekinthető élőhely vonatkozásában meghatározásra kerültek a kollégáimmal a közelmúltban összegyűjtött információk alapján. Az idős, háborítatlan lombhullató erdők jelentősége költőterületként kiemelkedő Közép-Európában, ahol alternatív fészkelőhelyek, pl. sziklapárkányok nem elérhetőek a faj számára.

A fiatal fekete gólyák tálplálék-összetételének vizsgálata ugyanazon élőhely-együttesben 8 egymást követő éven keresztül folyt, a faj kutatásának történetében egyedülállóan. Erre alapozva és terepi vizuális megfig.yelésekkel kiegészítve került meghatározásra a faj táplálékválasztására vonatkozó következtetés, valamint a fiókák táplálékösszetétele. A fekete gólya egyértelműen halevőnek mondható, és mint ilyen, nagymértékben vizes élőhely-függő faj.

Kimutattam, hogy a fekete gólya költési sikere összefüggésben van élőhelyének hidrológiai és meteorológiai jellemzőivel. Ez alapján – legalábbis azon európai területeken, ahol a vizsgált tényezők hasonlóan alakultak az elmúlt 15 évben, mint a Kárpát-medencében – a fekete gólya esélyei egy jelentős populáció-csökkenés elkerülésére nagymértékben függenek a csapadéktól, a nyári léghőmérsékletek alakulásától, valamint a fiókák etetéséhez szükséges táplálékforrások kellő mennyiségben való elérhetőségétől. Kutatási területemen a vízállások hosszútávú trendje negatív, és ez a halak szaporodási sikerének csökkenését vetíti előre. Ez arra a lehetőségre fig.yelmeztet, hogy a nem túl távoli jövőben a fekete gólya fő táplálékbázisa jelentősen lecsökkenhet. Ezért sürgető szükség van a folyó- és vizes élőhely-kezelési és rekonstrukciós stratégiák fölülvizsgálatára, valamint arra, hogy mielőbb földerítésre kerüljenek az esetleges alternatív lehetőségek a megfelelő táplálkozóhely biztosítására például a halastavak megfelelő üzemeltetésével.

A fekete gólya kutatásban elsőként adtam becslést gyűrűzési és megkerülési adatok alapján a faj élettartamára és túlélési rátáira. Eredményeim szerint a túlélési ráták az elsőéves és az idősebb egyedek esetében külömbözőek.

Saját, kollégáim és önkéntesek megfigyeléseire alapozva elsőként sikerült belátni, hogy a fekete gólya immatur egyedei visszatérnek Európába. Átnyaraló, 2. és 3. naptári évükben lévő egyedekből álló immatur csapatok számos alkalommal történt megfig.yelése támasztja ezt alá, melyek között színes gyűrűvel jelölt példányok is jelentős számban előfordultak. A diszperzió részletesebb elemzése nem igazolta azt a korábbi föltételezést, hogy a faj a keleti költőterületekről terjeszkedik nyugat felé.

Munkámban bemutattam, hogy az előzőleg föltételezett vonulási határok sokkal inkább széles átmeneti zónák, amely területekről az egyedek vonulási útvonal választásának mechanizmusa jelen tudásunk szerint nem ismert. Adatgyűjtésem, a gyűrűleolvasások, valamint a műholdas követések eredményeinek összevetésével kimutattam, hogy az európai fekete gólyák vonulási útvonalaira vonatkozó ismereteinket fölül kell vizsgálni. Léteznek a korábbi irodalomban le nem írt útvonalak: a Baltikumból a Fekete-tenger keleti partjai mentén a Kaukázus felé, valamint Oroszország európai területei irányából délkeleti irányban. Átfedések vannak a keleti és nyugati vonulású állományokban Közép-Európában, és várhatóan a telelőhelyeken is a közeljövőben igazolható lesz. A jelenleg ismert legkeletebbi telelőhelyű nyugati vonulású fekete gólya keletebbre telelt, mint a legnyugatabbra telelő keleti vonulású – ez a hurokvonulás lehetőségét is fölveti.

Kutatásaimban jelentős részt szenteltem a vizes élőhelyeknek, mint a fekete gólya számára fontos vonuláskori megállóhelyeknek. Csoportosítottam a táplálkozóhelyeket hidrológiai jellemzőik alapján, és vizsgáltam a jelentőségüket. Műholdas követési és terepi megfig.yelési eredményekre támaszkodva meghatároztam a három legjelentősebb megálló-területet a faj keleti vonulási útvonalán, melyeket főképpen emberi tevékenységekből adódó tényezők veszélyeztetnek. A fő veszélyeztető tényezőket jellemeztem.

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9 Literature

Altwegg R., Ringsby T.H., Saether B-E. 2000. Phenotypic correlates and consequences of dispersal in a metapopulation of house sparrows Passer domesticus. Journal of Animal Ecology 69: 762-770.

Aspinwall D.R. 1996. The Black Stork in Zambia - Conferencia International sobre la Cigüeńa negra Trujillo. (abstract only)

Ausden M (ed.) 2007. Habitat management for conservation. Oxford University Press. Oxford.

Bahat O. 2008. Wintering Black Storks (Ciconia nigra) cause severe damage to transmission lines in Israel – a study on the risk and mitigation possibilities. EDM International Conference on Overhead Lines, Fort-Collins, CO.

Bairlein F. 2001. Results of bird ringing in the study of migration routes and behaviour. Ardea 89 (1, suppl.): 7-19.

Batten L.A., Bibby C.J., Clement P., Elliott G.D., Porter R.F. 1990. Red data birds in Britain. T. & A.D. Poyser, London.

Bauer K.N., Glutz von Blotzheim U.N. 1966. Handbuch der Vögel Mitteleuropas. Akad. Verlagsgesellschaft, Frankfurt am Main.

Bayley P.B. 1991. The Flood Pulse Advantage and the Restoration of River-Floodplain Systems. Regulated Rivers Research and Management 6: 75-86.

Bayley P.B. 1995. Understanding large river-floodplain ecosystems. Bioscience 45: 153-160.

Bergen S.D., Bolton S.M., Fridley J.L. 2001. Ecological Engineering: Design based on ecological principles. Ecological Engineering 18(2):201-210.

Berthold P., Bauer H.G., Westhead V. 2001. Bird Migration: A General Survey. Oxford: Oxford University Press.

Beschta R.L., Bilby R.E., Brown G.W., Holtby L B., Hofstra T.D. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. in E. O. Salo and T. W. Cundy, editors. Streamside Management: Forestry and Fisheries Interactions. Institute of Forest Resources, Contribution No. 57, University of Washington, Seattle, WA. Pp.í 191-232

Bibby C.J. 1992. Conservation of migrants on their breeding grounds. Ibis 134 (suppl. 1): 29-34.

BirdLife International 2004. Birds in Europe: population estimates, trends and conservation status. Cambridge, UK: BirdLife International. (BirdLife International Conservation Series No. 12)

Bobek M, Pojer F., Peske L., Simek J. 2004. Wintering of Black Storks (Ciconia nigra) from the Czech republic in different parts of Africa, Aves 40 (1-4): 176-178.

Bobek M., Hampl R., Peske L., Pojer F., Simek J., Bures S. 2008. African Odyssey project – satellite tracking of Black Storks Ciconia nigra breeding at a migratory divide. J. Avian Biol. 39: 500-506.

Boyd H., Piersma T. 2001. Changing balance between survival and recruitment explains population trends in Red Knots Calidris canutus islandica wintering in Britain. Ardea 89: 301-3617.

Brice J.C. 1981. Stability of relocated stream channels, Federal Highway Administration, Offices of Research & Development, Environmental Division. Washington, D.C.

Brinson M.M., Malvárez A.I. 2002. Temperate freshwater wetlands: types, status, and threats. Environmental Conservation 29: 115-133 doi:10.1017/S0376892902000085

Brookes A. 1988. Channelized Rivers: Perspectives for Environmental Management. John Wiley and Sons. Chichester, U.K.

Brookes A. 1996. River Restoration Experiences in Northern Europe. A. Brookes and F. D. Jr. Shields, editors. River Channel Restoration: Guiding Principles for Sustainable Projects. John Wiley and Sons, Chichester, UK.

Cannell I. C., Mundy P. J. & Rockingham-Gill D. V. 1996. The Black Stork in Zimbabwe, 2nd International Conference on the Black Stork, Trujillo, Spain (abstract only)

Calvo B., Furness R.W. 1992. A review of the use and the effects of marks and devices on birds. Ringing & Migration 13 (3): 129-151. doi: 10.1080/03078698.1992.9674036

Caswell H. 2001. Matrix Population Models. Sinauer Associates, Sunderland.

Chevallier D., Baillon F., Robin J-P., Le Maho Y., Massemin-Challet S. 2008. Prey selection of the black stork in the African wintering area. Journal of Zoology 276: 276-284. DOI: 10.1111/j.1469-7998.2008.00488.x

Chevallier D., Duponnois R., Baillon F., Brossault P., Grégoire J-M., Eva H., Le Maho Y., Massemin S. 2010a. The importance of roosts for Black Storks Ciconia nigra wintering in West Africa. Ardea 98: 91-96.

Chevallier, D., Le Maho, Y., Baillon, F., Duponnois, R., Dieulin, C., Brossault, P., De Franclieu, P., Lorge, P., Aurouet, A., Massemin, S. 2010b. Human activity and the drying up of rivers determine abundance and spatial distribution of Black Storks Ciconia nigra on their wintering grounds, Bird Study 57 (3):369 — 380, DOI: 10.1080/00063651003678467

Chevallier D., Le Maho Y., Brossault P., Baillon F., Massemin S. 2011. The use of stopover sites by Black Storks (Ciconia nigra) migrating between West Europe and West Africa as revealed by satellite telemetry. J. Ornithol. 152: 1-13. DOI 10.1007/s10336-010-0536-6

Choquet R., Reboulet A.-M., Lebreton J.-D., Gimenez O., Pradel R. 2005. U-CARE 2.2 User's Manual. CEFE, Montpellier.

Choquet R., Reboulet A.-M., Pradel R., Gimenez O., Lebreton J.-D. 2004. M-SURGE: new software specifically designed for multistate capture recapture models. Animal Biodiversity and Conservation 27: 207-215.

Clobert J., Danchin E., Dhondt A., Nichols J.D. 2001. Dispersal. Oxford University Press, Oxford.

Cole G. 1976. Land drainage in England and Wales. Journal of the Institute of Water Engineers 30: 354-361.

Collar N.J., Stuart S.N. 1985. Threatened birds of Africa and related islands. The ICBP/IUCN Red Data Book. International Council for Bird Preservation/ International Union for Conservation of Nature & Natural Resources. Cambridge.

Collopy M.W. 1983. A comparison of direct observations and collections of prey remains in determining the diet of golden eagles. Journal of Wildlife Management 47: 360-368.

Corso A., Giordano A., Ricciardi D., Cardelli C., Celesti S., Romano L., Ientile R. 1999. Migrazione di Cicogna bianca Ciconia ciconia e Cicogna nera Ciconia nigra attraverso lo Stretto di Messina, Avocetta 23: 55 (in Italian)

Cramp S. (ed) 1977. The birds of the Western Palearctic, Oxford University Press Vol. 1: 323-328.

Cramp S., Simmons K.E.L. 1980. The Birds of the Western Palearctic Volume II. Oxford University Press, Oxford, New York, 695 p.

Cramp S. 1966. Studies of less familiar birds 139. Black Stork. - Brit. Birds., 59: 147-150

Croonquist M., Brooks R. 1991. Use of avian and mammalian guilds as indicators of cumulative impacts in riparian-wetland areas. Environmental Management 15: 701- 714. Doi: 10.1007/BF02589628

Danchin E., Boulinier T., Massot M. 1998. Conspecific reproductive success and breeding habitat selection: implications for the study of coloniality. Ecology, 79(7): 2415–2428.

del Hoyo J. (ed) 1992. Handbook of the Birds of the World, Lynxs Edicions Vol.1: 459.

Dementev G.P., Gladkov N.A. (eds.) 1951. Birds of the Soviet Union vol II. - Moskva, pp. 376-383.

Denac D. 2006. Resource-dependent weather effect in the reproduction of the White Stork Ciconia ciconia, ARDEA Vol. 94(2): 233-240.

Dennis N.B., Ellis D., Arnold J.R., Renshaw D. L. 1984. Riparian Surrogates in the Sacramento/ San Joaquin Delta and their Habitat Values.R. E. Warner and K. M. Hendrix, editors. California Riparian Systems: Ecology, Conservation and Productive Management. University of California Press, Berkeley, CA.

Diester E. 1994. The function, evaluation, and relicts of near-natural floodplains. Limnologie Aktuell – Band 2: Biologie der Donau. Gustav Fischer Verlag, Stutgart-Jena-New York.

Dolata P.T. 2010. Výsledky kroužkování čápů černých Ciconia nigra v jižní části Velkopolska (západní Polsko) v letech 2001-2010. In: Vránová S. (ed.). Metody a výsledky výzkumu ptačích populací V. Sborník abstraktů z celostátní ornitologické konference k 35. výročí založení Východočeské pobočky České společnosti ornitologické 22.-24.10.2010. VČP ČSO, Pardubice: pp.12-13. (abstract only)

Doligez B., Danchin E., Clobert J. 2002. Public Information and Breeding Habitat Selection in a Wild Bird Population. Science 297: 1168-1170.

Doligez B., Thomson D.L., van Noordwijk A.J. 2004. Using large-scale data analysis to assess life history and behavioural traits: the case of the reintroduced White stork Ciconia ciconia population int he Netherlands. Animal Biodiversity and Conservation, 27 (1): 387-402.

DPRP – Danube Pollution Reduction Programme (PCU UNDP/GEF) 1999. Evaluation of Wetlands and Floodplain Areas in the Danube River Basin. Final Report May 1999; Prepared by WWF Danube-Carpathian Programme and WWF-Auen Institute

Drescher E. 1936. Storchgewölle aus Schlesien. Ber. Ver. Schles. Orn. 21: 8. (in German)

Drent R., Both C., Green M., Madsen J., Piersma T. 2003. Pay-offs and penalties of competing migratory schedules. Oikos 103: 274-292.

Drower M. S. 1954. Water supply, irrigation and agriculture. in C. Singer, E. J. Holmyard, and A. R. Hall, editors. History of Technology. Clarendon Press, Oxford. pp 520-557

Dunning J.B.J., Stewart D.J., Danielson B.J., Noon B.R., Root T.L., Lamberson R.H., Stevens E. E. 1995. Spatially explicit population models: current forms and future uses. Ecological Applications

Ebersole J.L., Liss W.J., Frissell C.A. 1997. Restoration of Stream Habitats in the Western United States: Restoration as Reexpression of Habitat Complexity. Environmental Management 21: 1-14.

EURING Longevity List.

Faaborg J., Holmes R.T., Anders A.D., Bildstein K.L., Dugger K.M., Gauthreaux S.A., JR., Heglund P., Hobson K.A., Jahn A.E., Johnson D.H., Latta S.C., Levey D.J., Marra P.P., Merkord C.L., Nol E., Rothstein S.I., Sherry T.W., Sillett T.S., Thompson F.R. III & Warnock N 2010. Recent advances in understanding migration systems of New World land birds; Ecological Monographs, 80(1): 3–48.

Faulkner S. 2004 Urbanization impacts on the structure and function of forested wetlands. Urban Ecosystems vol 7(2): 89- 106 Doi: 10.1023/B:UECO.0000036269.5624

Francis C.M. 1995. Estimating survival rates from recoveries of birds ringed as young: A case study, Journal of Applied Statistics, 22 (5-6): 567 – 578.

Fretwell S.D., Lucas H.L. 1970. On territorial behavior and other factors influencing habitat distribution in birds. Acta Biotheoretica 19:16-36.

Fontaneto C., Ferretti G., Bordignon L., Fontaneto D. 2006. The Black Stork Ciconia nigra in northern Italy: Which environmental features does this species need to nest? Revue d'écologie 61 (3): 303-308.

Goda L., Kalocsa B., Tamás E.A. 2007. Riverbed erosion on the Hungarian section of the Danube, Journal of Environmental Science for Sustainable Society, 1: 47-54.

Gonzáles, J.L., Merino, M. 1988. Censo de la población espańola de Cigüeńa negra. - Quercus, 30: 12-17. (in Spanish)

Gore J.A., Shields F.D. Jr. 1995. Can large rivers be restored? Bioscience 45: 142-152.

Griffin G., Morris J., Rodgers J., Snyder B. 2008. Changes in Wood Stork (Mycteria americana) nestling success observed in four Florida bird colonies during the 2004, 2005, and 2006 breeding seasons. Acta Zoologica Academiae Scientiarum Hungaricae 54 (Suppl. 1):123–130.

Grischenko V.N. 1995. Some observations on the nomadic group of Black Storks in June. Berkut 4 (1-2): 94. (in Russian with English summary)

Guti G. 2005. Importance of lateral connectivity of the Danubian floodplains from the point of view of conservation of fish biodiversity. In: Tamás E.A. (ed.) Élet a Duna-ártéren, BITE, Baja. pp. 51-57.

Haffner C. (ed) 1999. Conservation and Sustainable Management of Forests in Central and Eastern European Countries. EU Phare Environment Consortium.

Hagvar S., Hagvar G., Monnes E. 1990. Nest site selection in Norwegian woodpeckers. Holarctic Ecology 13: 156-165.

Hahn S.S. 1982. Stream channelization; effects on stream fauna. in P. E. Greeson, editor. Biota and biological principles of the aquatic environment. U. S. Geological Survey: Circular. pp 43-49

Hampl R., Bures S., Balaz P., Bobek M., Pojer F. 2005. Food Provisioning and Nestling Diet of the Black Stork in the Czech Republic, Waterbirds, 28 (1): 35–40.

Hancock J., Kushlan J., Kahn, P. 1992. Storks, Ibises and Spoonbills of the World. Academic Press, London.

Hanski I., Gilpin M.E. (eds.) 1997. Metapopulation biology: ecology, genetics and evolution, Academic Press, San Diego.

Hanski I. 1999. Metapopulation Ecology, Oxford University Press, Oxford.

Haraszthy L. (ed) 1984. Magyarország fészkelő madarai. Natura, Budapest. (in Hungarian)

Helland I.S. 1990. PLS regression and statistical models. Scandinavian Journal of Statistics, 17: 97–114.

Hildén O. 1965. Habitat selection in birds. - Ann. Zool. Fenn., 2: 53-75.

Homonnay N. 1943. Beitrage zur Kenntnis der Nistplatze und der Verbreitung des Schwarzen Storches (Ciconia nigra L.) in Ungarn. Frag. Faun. Hungarica 6: 9-19. (in German)

Horváth M., Szitta T., Firmánszky G., Solti B., Kovács A., Moskát Cs. 2010. Spatial variation in prey composition and its possible effect on reproductive success in an expanding Eastern Imperial Eagle (Aquila heliaca) population, Acta Zoologica Academiae Scientiarum Hungaricae 56 (2):187–200.

Hunt C. 1985. The need for riparian habitat protection.National Wetlands Newsletter 7: 5–8.

Hunter Jr. M.L. 1999. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press, Cambridge.

Imbeau L., Mönkönnen M., Desrochers A. 2000. Long-term effects of forestry on birds of the eastern Canadian boreal foress: a comparison with Fennoscandia. Conservation Biology 15.: 1151-1162.

Ivey G.L., Dugger B.D. 2008. Factors Influencing Nest Success of Greater Sandhill Cranes at Malheur National Wildlife Refuge, Oregon, Waterbirds Vol. 31(1): 52-61.

Jadoul G. 1998. Cigogne noire. N° spécial Science & Nature magazine, (in French)

Janssen G., Hormann M., Rohde C. 2004. Der Schwarzstorch, Die Neue Brehm-Bücherei Bd. 468., Westarp Wissenschaften, Hohenwarsleben. (in German)

Jenni L., Schaub M. 2003. Behavioural and psysiological reactions to environmental variation in bird migration: a review. In: Berthold P., Gwinner E., Sonnenschein E. (eds) Avian migration. Springer, Berlin Heidelberg New York, pp. 155-171.

Jiguet F., Gadot A.-S., Julliard R., Newson S.E., Couvet D. 2007. Climate envelope, life history traits and the resilience of birds facing global change. Global Change Biology, 13: 1672–1684. doi: 10.1111/j.1365-2486.2007.01386.x

Jiguet F., Barbet-Massin M., Chevallier D. 2011. Predictive distribution models applied to satellite tracks: modelling the western African winter range of European migrant Black Storks Ciconia nigra. J. Ornithol. 152: 111-118. DOI 10.1007/s10336-010-0555-3

Johnson B.L., Richardson W.B., Naimo T.J. 1995. Past, Present and Future Concepts in Large River Ecology. BioScience 45: 134-141.

Johst K., Brandl R. 1997 Evolution of dispersal: the importance of the temporal order of reproduction and dispersal. Proc. R. Soc. Lond. B 264: 23-30.

Jovani R., Tella J.L. 2004. Age-related environmental sensitivity and weather mediated nestling mortality in white storks Ciconia ciconia. Ecography. 27: 611–618.

Junk W.J., Bayley P.B., Sparks R.E. 1989. The flood pulse concept in river floodplain system. Proceedings of the International Large River Symposium: Ontario, Canada, 1986 106: 110-127.

Kaatz C., Kaatz M. 1995. Satellite telemetry of the White Stork – a basis for new conservation concepts. In: Biber O., Enggist P., Marti C., Salathé T. (eds) Proceedings of the International Symposium on the white stork (western population). Basel.

Kalocsa B., Tamás E. 1996a. The status of the Black Stork in Hungary, II. Conference Internationale sobre la Cigüeña Negra, ADENEX, Spain (abstract only)

Kalocsa B., Tamás E.A. 1996b. Nesting of Black Storks in the Gemenc floodplain forest, II. Conference Internationale sobre la Cigüeña Negra, ADENEX, Spain (abstract only)

Kalocsa B., Tamás E.A. 2002a. A fekete gólya (Ciconia nigra) állományának felmérése a gemenci erdőben – fészkelési szokások és költési eredményesség (1992-2000). Aquila 107-108: 215-223. (in Hungarian with English abstract)

Kalocsa B., Tamás E. 2002b. Data on the diet of the Black Stork (Ciconia nigra), 1996-2000. Aquila 107-108: 421-427. (in Hungarian with English abstract)

Kalocsa B., Tamás E.A. 2002c. Fekete gólyák (Ciconia nigra) nemzetközi színes gyűrűzési programja és ennek magyarországi vonatkozásai (1994-2000), Aquila 107-108: 249-257. (in Hungarian with English abstract)

Kalocsa B., Tamás E.A. 2002d. Fekete gólyák (Ciconia nigra) számára készített műfészkekkel kapcsolatos tapasztalatok Gemencben (1996-2000) Aquila 107-108: 259-263. (in Hungarian with English abstract)

Kalocsa B., Tamás E. 2003. Duna-Dráva Nemzeti Park Gemenci Tájegység - Vén-Duna élőhely-revitalizációs program II. ütem és monitoringja/Kétéltű- és madárfauna monitoring, (manuscript, in Hungarian)

Kalocsa B., Tamás E.A. 2004a. Black Stork colour ringing and recoveries in Hungary, 1994-2000., AVES 40 (1-4): 109-117.

Kalocsa B., Tamás E. 2004b. Addendum to the diet of the Black Stork (Ciconia nigra) in the Gemenc Region of the Danube-Drava National Park, Hungary 1996-2000. AVES 40 (1-4): 75-83.

Kalocsa B., Tamás E. 2004c. Fekete gólya védelmi program beszámolója. Heliaca 1: 36-37. (in Hungarian with English abstract)

Kalocsa B., Tamás E. 2004d. Status of the Black Stork in Hungary in the year 2000. AVES 40 (1-4): 45-49.

Kalocsa B., Tamás E. 2005: Fekete gólya-védelmi program – 2005. Heliaca 2: 33-44. (in Hungarian with English abstract)

Kalocsa B., Tamás E.A. 2006. An analysis of nesting data of Black Storks Ciconia nigra in the Gemenc region of the Danube Drava National Park (1992-2003). Biota 7 (1-2): 47-50.

Kalocsa B., Tamás E.A. 2007. Feketególya-védelmi program. Heliaca 4: 51-53. (in Hungarian with English abstract)

Kalocsa B., Tamás E.A. 2009a. A fekete gólya. in: Magyar Madárvonulási Atlasz; (in Hungarian with English abstract)

Kalocsa B., Tamás E.A. 2009b. Feketególya-védelmi program – 2008, Heliaca 6: 33-37. (in Hungarian with English abstract)

Kalocsa B., Tamás E. A. 2010. A fekete gólya védelmi program 2009. évi beszámolója. Heliaca 7: 59-64. (in Hungarian with English abstract)

Kalocsa B., Zsuffa I. 1998. Vízszintsüllyedések a Dunán, Journal Hungar. Hydrol. Soc. 78. (in Hungarian)

Kanyamibwa, S., Schierer A., Pradel R., Lebreton J. D.1990. Changes in adult annual survival rates in a western European population of the White Stork Ciconia ciconia. Ibis 132:27-35.

Kirwan G.M., Boyla K., Castell P., Demirci B., Özen M., Welch H., Marlow T. 2008. The Birds of Turkey; Cristopher Helm London, 2008. 512 p.

Kluyver R.W., Tinbergen L. 1953. Territory and regulation of density in titmice. Archives Neerandaises de Zoologie 10: 265-286.

Knight R. L. 1988. Relationship of birds of prey and riparian habitat in the Pacific Northwest: An overview. in K. J. Raedeke, editor. Streamside Management: Riparian Wildlife and Forestry Interactions. Institute of Forest Resources Contribution No. 59. University of Washington, Seattle, WA. pp 79-91

Korpimaki E. 1984. Population dynamics of birds of prey in relation to fluctuations in small mammal populations in western Finland. Ann. Zool. Fennici 21: 287-293.

Kosicki J.Z., Profus P., Dolata P.T., Tobólka M. 2006. Food composition and energy demand of the White Stork Ciconia ciconia breeding population. Literature survey and preliminary results from Poland. In: Tryjanowski P., Sparks T.H., Jerzak L. (eds) The White Stork in Poland: studies in biology, ecology and conservation. Bogucki Wydawnictvo Naukowe, Poznan.

Krebs C.J. 2001. Ecology: the experimental analysis of distribution and abundance. Benjamin Cummings, Menlo Park.

Krejcie R.V., Morgan D.W. 1970. Determining sample size for research activities Educational and Psychological Measurement, 30: 607-610.

Lack D. 1944. Ecological aspects of species-formation in passerine birds. Ibis, 86: 260-286.

Lack D. 1949. The significance of ecological isolation in: Jepsen G.L., Mayr E., Simpson G.G.: Genetics, paleontology and evolution. Princeton, pp. 299-308.

Lakhani K. H., Newton I. 1983. Estimating Age-Specific Bird Survival Rates from Ring Recoveries-Can it be Done?, Journal of Animal Ecology, 52 (1): 83-91

Lakhani K. H. 1987. Efficient Estimation of Age-Specific Survival Rates from Ring Recovery Data of Birds Ringed as Young, Augmented by Field Information, Journal of Animal Ecology, 56 (3): 969-987

Lawrence A.B. Jr., Robinette J.R. 2008. Breeding Success of Wood Storks Nesting in Georgia and South Carolina, Waterbirds 31(1): 19-24.

Lebedeva M.I. 1959. Biology of the Black Stork (*Ciconia nigra*) in the Belovezskoi forest. - Ornitologiya, 2: 138-142.

Lebreton J-D. 1978. Une modele probabiliste de la dynamique des populations de Cicogne blanche Ciconia ciconia L. en Europe occidentale. Biométrie et Ecologie. Société Francaise de Biométrie, Paris. Pp. 277-343. (in French)

Lebreton J-D., Clobert J. 1991. Bird population dynamics, management, and conservation: the role of mathematical modeling. Bird Popullation Studies: Relevance to Conservation and Management. Oxford University Press, Oxford. Pp. 105-125.

Leimar O., Norberg U. 1997 Metapopulation extinction and genetic variation in dispersal-related traits. Oikos 80: 448-458.

Levin S.A., Cohen D., Hastings A. 1984 Dispersal in patchy environments.Theor. Popul. Biol. 26: 165-191.

Lewis S.B., Fuller M.R., Titus K. 2004. A comparison of 3 methods for assessing raptor diet during the breeding season. Wildlife Society Bulletin 32: 373-385.

Löhmus A., Sellis U. 1996. A theoretical approach to the habitat selection studies on the Black Stork. II. Conference Internationale sobre la Cigüeña Negra, ADENEX, Spain (abstract only)

Löhmus A., Sellis U., Rosenvald R. 2005. Have recent changes in forest structure reduced the Estonian black stork Ciconia nigra population? Biodiversity and Conservation 14: 1421-1432. DOI: 10.1007/s10531-004-9667-5

Löwis O. 1893. Baltic birds. Riga. 149 p. (In Latvian)

Luthin C.S. 1987. Status of and conservation priorities for the World's stork species. Colonial Waterbirds 10(2): 181-202.

Lynch J.A., Corbett E.S., Hoopes R. 1977. Implications of forest management practices on the aquatic environment. Fisheries 2: 16-22.

Madrono A., Palacios C.J., de Juana A.E. 1992. La migracion de la Ciguena Negra Ciconia nigra a traves de Espana peninsular; Ardeola 39(1), 1992. 9-13., (in Spanish)

Mahieu M., Jadoul, G. 2004. Etude de la qualité des ruisseaux utilisés par un couple de Cigognes noires pour la pêche, Aves 40 (1-4): 100-104. (in French with English abstract)

Mann H. B., Whitney D. R. 1947. On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other. Annals of Mathematical Statistics 18 (1): 50–60.

Marchand M., Marteijn E.C.L., Bakonyi P. 1995. Policy analysis as a tool for habitat restoration: a case study on the Danube River floodplain, Hungary. in S. H. Hosper, R. D. Gulati, L. Van-Liere, and R. M. M. Rooijackers, editors. Integrated Water Resources Management. International Conference on Integrated Water Resources Management (Netherlands). pp 179-186

Marković J., Orlović, S. 2002. Plantaže topola i zaštita vlažnih staništa i biodiverziteta: Praktično i ekonomski opravdano protiv romantičnog i deklarativnog. Šume 67: 19-26. (in Serbian)

Martin T.E. 1987. Food as a limit on breeding birds: A life-history perspective. Annu. Rev. Ecol.Syst. 18: 453-487.

McDonald P.G., Olsen P.D., Cockburn A. 2004. Weather dictates reproductive success and survival in the Australian brown falcon (*Falco berigora*). Journal of Animal Ecology: 683-692.

Mearns R., Newton I. 1988. Factors affecting breeding success of peregrines in south Scotland. Journal of Animal Ecology: 903-916.

Meffe G.K., Carroll C.R. 1994. Principles of Conservation Biology. Sinauer Associates, Sunderland, Massachusetts.

Mitsch W.J., Gosselink J.G. 1993. Wetlands. Van Nostrand Reinhold, New York. 722 pp.

Moore F.R., Simons T.R. 1992. Habitat suitability and stopover ecology of neotropical landbird migrants. In: Hagen J.M., Johnson D.W. (eds) Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington DC, pp. 345-355.

Moore F.R., Gauthreaux S.A., Kerlinger P., Simons T.R. 1995. Habitat requirements during migration: important link in conservation. In: Martin T.E., Finch D.M. (eds) Ecology and management of neotropical birds. Oxford University Press, Oxford, pp. 121-144.

Moss R., Oswald J., Baines D. 2001. Climate change and breeding success: decline of the capercaillie in Scotland. Journal of Animal Ecology 70: 47-61.

Newton I. 1998. Population limitation in birds. Academic press. London.

Newton, I. 2004. Population limitation in migrants. Ibis 146: 197-226.

Newton, I. 2006. Can conditions experienced during migration limit the population levels of birds? J. Ornithol. 147: 146-166.

Newton I. 2008. The Migration Ecology of Birds.. Elselvier.

Ogden J.C., Kushlan J.A., Tilmant J.T. 1978. The food habits and nesting success of Wood Storks in Everglades National Park 1974. U.S. Dept.of the Interior, National Park Service, Natural Resources Report Number 16.

Pande S.A., Pawashe A., Deshpande P.S., Kasambe R., Mahabal A.S. 2006. Recent records, review of wintering distribution, habitat choice and associations of Black Stork Ciconia nigra in India and Sri Lanka. Biota 7 (1–2): 65–75.

Paradis E., Baillie S.R., Sutherland W.J., Gregory R.D. 1998. Patterns of natal and breeding dispersal in birds. Journal of Animal Ecology 67: 518-536.

Parkes C. 2004. VHF radio telemetry monitoring of satellite marked migrating Black Storks (Ciconia nigra) across the Straits of Gibraltar, AVES, 40 (1-4): 122-126.

Peirson G., Bolland J.D., Cowx I. 2008. Lateral dispersal and displacement of fish during flood events in lowland river systems in the UK– implications for sustainable floodplain management. Ecohydrology and Hydrobiology 8 (2-4): 363-373.

Petkov N., Iankov P., Georgiev D. 2006. Recent status and changes in the breeding population of the Black Stork Ciconia nigra in Bulgaria. Biota 7(1—2): 77-82.

Pieczka I., Bartholy J., Pongrácz R., Hunyady A. 2010. Climate Change Scenarios for Hungary Based on Numerical Simulations with a Dynamical Climate Model, Large-Scale Scientific Computing, Lecture Notes in Computer Science 5910: 613-620.

Pierotti R., Annett C.A. 1990. Diet and Reproductive Output in Seabirds. BioScience 40 (8): 568-574

Poff N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard K.L., Richter B.D., Sparks R.E., Stromberg J.C. 1997. The Natural Flow Regime. BioScience. 47(11): 769-784

Pojer F. 1996. The Black Stork in the Czech Republic: present status and ecology. II. Conference Internationale sobre la Cigüeña Negra, ADENEX, Spain (abstract only)

Pojer F. 2009. Hnízdí u nás nasi cápi cerny? Ochrana Prírody (4): 18-22. (In Czech)

Poulsen D.O. 2002. Avian richness and abundance in temperate Danish forest: tree variables important to birds and their conservation. Biodiversity and Conservation 11: 1551-1566.

Pradel R., Johnson A.R., Viallefont A., Nager R.G., Cézilly F. 1997. Local recruitment in the Greater flamingo: a new approach using capture-mark-recapture data. Ecology, 78: 1431-1445.

Profus P. 1994. Black Stork Ciconia nigra. In: Tucker G., Heath M. (eds.): Birds in Europe: Their conservation status. BirdLife Conservation Series No 3. Birdlife International, Cambridge. Pp: 98-99.

Pulliam H.R., Danielson B.J. 1991. Sources, sinks, and habitat selection: a landscape perspective on population dynamics. The American Naturalist. 137 (suppl): S50-S66.

Putzig P. 1935. Neue Untersuchungen über die Nahrung des weissen Storches. Deutsche Jagd. 5 (7): 256-257. (in German)

Puzović S., Grubač B. 2000. federal republic of Yugoslavia. In: Heath M.F., Evans, M. I. (eds.): Important Bird Areas in Europe: Priority sites for conservation. Volume 2: Southern Europe. BirdLife International, Cambridge. Pp: 725-745.

Puzović S., Sekulić V., Pavlović, D. 1989. Black Stork (Ciconia nigra L.) at Obedska bara 1983-1987. Bulletin of Natural History Museum Belgrade B43/44: 161-174.

Rebane M., Waliczky Z., Turner R. 1997. Boreal and temperate forests. In: Tucker G., Evans M. (eds.): Habitats for birds in Europe: a conservation strategy for the wider environment. BirdLife International, BirdLife Conservation Series No. Cambridge. Pp. 203-238.

Redpath S.M., Clarke R., Madders M., Thirgood S.J. 2001. Assessing raptor diet: comparing pellets, prey remains, and observational data at hen harrier nests. Condor 103: 184-188.

Rosenvald R., Löhmus A. 2003. Nesting of the Black Stork (Ciconia nigra) and white-tailed eagle (Haliaeetus albicilla) in relation to forest management, Forest Ecology and Management, 185 (3). 217-223.

Roslyakov A.G., Voronov B.A., Darman Y.A., Parilov M.P., Gorobeiko V.V. 2004. Black Stork (Ciconia nigra) in northern Pryamurje and adjoining territories of far eastern Russia, Aves, 40 (1-4): 61-68.

Rutz C. 2003. Assessing the breeding season diet of Goshawks Accipiter gentilis: biases of plucking analysis quantified by means of continuous radio monitoring. Journal of Zoology 259: 209-217.

Ryder J.H., Ryder B.A. 1978. First breeding records of Black Stork in Malawi. Ostrich, 49: 51.

Sackl P. 1987. Über saisonale und regionale Unterschiede in der Ernahrung und Nahrungswahl des Weiss storches (Ciconia c. ciconia) im Verlauf der Brutperiode. Egretta 30: 49-80. (in German)

Sackl P., Strazds M. 1997. Ciconia nigra Black Stork. In: Hagemeier W., Blair M. (eds): The EBCC Atlas of European Breeding Birds. T & A D Poyser, London. Pp. 56-57.

Schaub M, Pradel R., Lebreton J-D. 2004. Is the reintroduced White stork (Ciconia ciconia) population in Switzerland self-sustainable? Biol. Cons. 119: 105-114.

Schneberger E., Funk J.L. 1972. Stream channelization: a symposium, North Central Division, American Fisheries Society; 2. Madison, WI.

Schneider–Jacoby M. 1999. Breeding distribution and ecology of the Black Stork Ciconia nigra in the Sava alluvial wetlands, Croatia. Acrocephalus 20 (97): 167-176.

Schulze P.C. (ed) 1996. Engineering Within Ecological Constraints. National Academy of Engineering, National Academy Press. Washington, D.C.

Sekercioglu C.H. 2007. Conservation ecology: area trumps mobility in fragment bird extinctions. Current Biology 17 (8): 283–286.

Sellis U. 2004. Will the Black Stork (Ciconia nigra) remain as a breeding species in Estonia? Aves 40 (1-4): 205-206.

Senra A., Alés E.E. 1992. The decline of the White stork Ciconia ciconia population of Western Andalusia between 1976 and 1988: causes and proposals for conservation. Biol. Cons. 61: 51-57.

Shapiro S.S., Wilk M.B. 1965. An analysis of variance test for normality (complete samples). Biometrika 52 (3-4): 591–611.

Sherry T. W., Holmes R. T. 1995. Summer versus winter limitation of populations: what are the issues and what is the evidence? in T. E. Martin and D. M. Finch, editors. Ecology and management of Neotropical migratory birds. Oxford University Press, New York, New York, USA, pp. 85–120.

Siegfried W.R. 1967. The distribution and status of the Black Stork in Southern Africa - Ostrich 38 (3): 179-185. DOI: 10.1080/00306525.1967.9634265

Simit D. 2008. Black Stork Migration at the Bosphorus Strait, Turkey; V. International Conference on the Black Stork, Uzlina, Romania, 2008. (abstract only)

Simmons R.E., Avery D.M., Avery G. 1991. Biases in diets determined from pellets and remains: correction factors for a mammal and bird-eating raptor. Journal of Raptor Research 25: 63-67.

Simpson P.W., Newman J.R., Keirn M.A., Matter R.M., Guthrie P.A. 1982. Manual of Stream Channelization Impacts on Fish and Wildlife. Fish and Wildlife Service. Washington, DC.

Southern H.N. 1970. The natural control of a population of tawny owls (Strix aluco). Journal of Zoology 162:197-285.

Stanford J.A., Ward J.V. 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. in K. Lubinski, J. Wiener, and N. Bhowmik, editors. International Conference, Sustaining the Ecological Integrity of Large Floodplain Rivers. July 12-15 La Crosse, WI 1994. pp 105-119

Stauffer F., Best L.B. 1980. Habitat Selection by Birds of Riparian Communities: Evaluating Effects of Habitat Alterations. The Journal of Wildlife Management. 44 (1): 1-15

Stearns S.C. 1992. The Evolution os Life Histories. Oxford University Press. Oxford.

Steenhof K., Kochert M.N., Carpenter L.B., Lehman R.N. 1999. Long-term prairie falcon population changes in relation to prey abundance, weather, land uses and habitat conditions. The Condor 101: 28-41.

Stojanović V. 2002. Specijalni rezervat prirode "Gornje Podunavlje" – geografski prikaz, zaštita, korišćenje. Prirodno – matemetički fakultet, Institut za geografiju, turizam i hotelijerstvo, Novi Sad. (in Serbian)

Strazds M., Meiers H., Petrins A. 1996. Analysis of ecological conditions of breeding habitat of the black storks in Latvia. II. Conference Internationale sobre la Cigüeña Negra, ADENEX, Spain (abstract only)

Strazds M. 2004. Conservation status of the Black Stork (Ciconia nigra) in Europe and in the World, Aves, 40 (1-4): 12-13. (abstract only)

Szijj J., Szijj L. 1955. Contributions to the food-biology of the White stork (Ciconia c. ciconia L.). Aquila 59-62: 83-94.

Tamás E., Kalocsa B. 2005. Management-related problems of floodplain habitats of the Black Stork (Ciconia nigra), Archiv für Hydrobiologie, Suppl. 155 (1-4): 483-490.

Tamás E.A., Kalocsa B. 2006. The diet of youngs and the feeding places of Black Storks Ciconia nigra in Gemenc, Biota 7 (1-2): 103-108.

Tamás E.A., Kalocsa B., Strazds M. 2006. Foreword to the Proceedings of the 4th International Conference on the Black Stork Ciconia nigra, Biota 7 (1-2): 5-6.

Tamás E.A., Zellei L., Sziebert J., Szlavik L., Kalocsa B. 2006: Determination of status, processes and targets in the planning of the nature protection aspect rehabilitation of the southern Hungarian Danube floodplains. Geophysical Research Abstracts 8: 10267.

Tarboton W. 1982. Breeding status of the Black Stork in the Transvaal. - Ostrich 53: 151-156.

Tockner K., Schiemer F. 1997. Ecological aspects of the restoration strategy for a river-floodplain system on the Danube River in Austria. Global Ecology and Biogeography Letters 6: 321-329.

Tornberg R., Reif V. 2007. Assessing the diet of birds of prey: a comparison of prey items found in nests and images. Ornis Fennica 84: 21-31.

Tortosa F.S., Castro F. 2003. Development of thermoregulatory ability during ontogeny in the White Stork Ciconia ciconia. Ardeola. 50: 39–45.

Travis J.M.J., Dytham C. 1998 The evolution of dispersal in a metapopulation: a spatially explicit, individual-based model. Proc. R. Soc. Lond. B 265: 17-23.

Treinys R., Löhmus A., Stoncius D., Skuja S., Drobelis E., Sablevicius B., Rumbutis S., Dementavicius D., Narusevicius V., Petraska A., Augustis D. 2008. At the border of ecological change: status and nest sites of the Lithuanian Black Stork Ciconia nigra population 200-2006 versus 1976-1992. J. Ornithol. 149:75-91. DOI: 10.1007/s10336-007-0220-7

Tucakov M., Kalocsa B., Mikuska T., Tamás E. A., Zuljevic A., Erg B. & Deme T. 2006. The Black Stork Ciconia nigra between the Sió channel and the Drava river in the central Danube floodplain: transboundary monitoring and protection plan, Biota 7 (1-2): 109-118.

Urcun J.P. 2004. The autumn migration of the Black Stork (Ciconia nigra) through the Pyrenees, les Actes de la IIIéme Conference Internationale sur la Cigogne noire, Aves, 40 (1-4): 140-154.

Valone T.J., Templeton J.J. 2002. Public information for the assessment of quality: a widespread social phenomenon. Phil. Trans. R. Soc. Lond. B 357: 1549–1557. DOI 10.1098/rstb.2002.1064

van den Bossche W. 1996. Migration of the Black Stork in Israel, 2nd International Conference on the Black Stork, Trujillo, Spain, 21-24. March 1996, (Abstract only).

van den Bossche W. 2004. Black Storks (Ciconia nigra) wintering in Northern Israel, AVES, 40 (1-4): 127-239.

Villarubias S., Brossault P., Sériot J. 2004. La cigogne noire (Ciconia nigra) en France. Révision du statut de l'effectif nicheur, Aves, 40 (1-4): 50-60. (in French with English abstract)

Ward J.V. 1989. The four dimensional nature of lotic ecosystems. Journal of the North American Benthological Society 8: 2-8.

Wayne R.M., Shamis J. D. 1977. An Annotated Bibliography of Bird Marking Techniques. Bird-Banding 48 (1): 42-61

Wiens J. 1976. Population responses to patchy environments. Annual Review of Ecology and Systematics 7:81–120.

Wold H. 1985. Partial least squares. Samuel Kotz and Norman L. Johnson, eds. Encyclopedia of statistical sciences, 6: 581-591.

Wold H. 1994. PLS for multivariate linear modeling. H. van der Waterbeemd, ed. QSAR: Chemometric methods in molecular design: Methods and principles in medicinal chemistry. Weinheim, Germany: Verlag-Chemie.

Zduniak P. 2010. Water conditions influence nestling survival in a Hooded Crow *Corvus cornix* wetland population. J. Ornithol. 151: 45-50.

Zeitz R., Daróczi J. Sz., Komáromi I., Kovács I., Ölvedi Sz. 2008. Autumn migration dynamics of Black Stork (Ciconia nigra) on the Măcin watchsite (South-East Romania) between 2002–2007; V. International Conference on the Black Stork, Uzlina, Romania, 2008. (abstract only)

Zielinsky P. 2006. The role of forest reserves in the protection of the Black Stork Ciconia nigra in central Poland, Biota, 7(1-2): 119-123.

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Dolata, Pawel T. a Polish ornithologist. Very active in Black Stork colour ringing programme in Poland from the start.

Hovel, Haim (Hajós György) a machine engineer and ornithologist, who was born in Hungary, but in 1949 he immigrated to Israel and over the next 50 years has become a famed ornithologist and bird watcher.

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10 Annexes

Annex 1. assessment of all explanatory variables (mean waterlevel spring, mean waterlevel summer, length of rainy periods, summa precipitation, mean May temperature and mean June temperature) in Black Stork nestling success, 1996-2010, yearly.

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		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AVERAGE WATERLEVEL	February	192	246	186	364	518	303	449	342	318	280	212	286	241	207	204
	March	229	396	280	620	601	454	508	327	328	377	379	365	383	501	371
	April	488	374	314	488	652	506	403	271	399	556	793	248	385	600	331
	MEAN 2-4	303.00	338.67	260.00	490.67	590.33	421.00	453.33	313.33	348.33	404.33	461.33	299.67	336.33	436.00	302.00
	May	521	437	289	641	546	423	380	315	347	522	600	248	404	445	467
	June	402	350	303	598	378	448	363	278	465	349	602	273	390	428	753
	July	404	671	332	520	317	381	280	156	364	446	341	287	375	628	401
	MEAN 5-7	442.33	486.00	308.00	586.33	413.67	417.33	341.00	249.67	392.00	439.00	514.33	269.33	389.67	500.33	540.33
RAIN	LENGTH	4	3	4	4	2	8	2	3	6	5	6	6	5	4	9
	SUMMA	133.70	115.70	117.20	152.10	37.00	204.00	84.70	47.70	139.50	119.40	137.30	141.40	161.90	122.90	332.90
Mean daily t May		17.74	16.87	15.57	16.10	18.64	13.77	16.71	15.39	14.36	13.32	12.29	16.30	17.12	14.82	14.43
Mean daily t June		20.41	20.03	21.21	19.99	21.94	14.71	18.77	21.55	20.95	20.34	19.74	19.13	19.40	17.13	17.97
AVG BS YOUNG		3.31	2.58	2.36	2.72	4.05	2.25	2.73	3.13	2.00	2.40	2.38	2.81	2.20	3.08	1.50
EVALUATION	FISH	BAD	BAD	BAD	GOOD	GOOD	GOOD	GOOD	BAD	BAD	GOOD	GOOD	BAD	BAD	GOOD	BAD
	FOOD	GOOD	GOOD	BAD	BAD	GOOD	GOOD	BAD	BAD	BAD	GOOD	BAD	BAD	BAD	BAD	BAD
	RAIN mm	GOOD	GOOD	GOOD	BAD	GOOD	BAD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	BAD	GOOD	BAD
	RAIN length	BAD	GOOD	BAD	BAD	GOOD	BAD	GOOD	GOOD	BAD	BAD	BAD	BAD	BAD	BAD	BAD
	T May	GOOD	GOOD	BAD	GOOD	GOOD	BAD	GOOD	BAD	BAD	BAD	BAD	GOOD	GOOD	BAD	BAD
	T June	GOOD	GOOD	GOOD	BAD	GOOD	BAD	BAD	GOOD	GOOD	GOOD	BAD	BAD	BAD	BAD	BAD

Annex 2. Live encounter matrix of Black Storks colour-ringed in Hungary, 1994-2009; where n_{ri}=number of ringed individuals and n_{re}=number of live encounters in the respective year.

year	n_{ri}	n_{re}																
	ringed	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
1994	13	1	0	2	1	0	0	0	0	0	0	1	0	0	1	1	1	8
1995	33		5	3	1	0	0	1	0	0	0	0	1	1	0	0	0	12
1996	53			5	3	0	1	0	0	0	1	1	2	0	0	0	0	13
1997	52				2	0	1	1	0	1	2	0	0	1	1	0	0	9
1998	33					0	0	0	0	0	0	2	1	1	0	0	0	4
1999	67						11	6	2	1	0	0	0	2	1	1	1	25
2000	46							1	0	0	0	0	0	0	0	0	0	1
2001	71								1	1	2	1	1	1	0	1	0	8
2002	76									3	1	1	1	1	0	1	2	10
2003	53										0	1	3	0	0	3	2	9
2004	76											3	4	3	3	5	2	20
2005	93												8	6	4	4	1	23
2006	65													11	2	4	5	22
2007	164														14	10	12	36
2008	72															3	1	4
2009	102																31	31
TOTAL	1069	1	5	10	7	0	13	9	3	6	6	10	21	27	26	33	58	235

Annex 3. Hungarian-related observations of Non-Breeding subadults in breeding range.

Ring no.	ringed		observed					co-ordinates			
(CR)	Year	Place	Year	Place	Age (cy)	Distance (km)	Direction	ringing lat	ringing lon	observation lat	observation lon
542	1996	Báta	1997	Dunafalva	2	4	SE	46,12	18,77	46,09	18,80
56C	1997	Homorúd	1999	Baja	3	30	NNE	45,58	18,49	46,18	18,90
580	1999	Baja	2000	Baja	2	5	E	46,18	18,90	46,18	18,90
583	1999	Baja	2000	Baja	2	5	E	46,18	18,90	46,18	18,90
583	1999	Baja	2001	Baja	3	5	E	46,18	18,90	46,18	18,90
584	1999	Baja	2000	Baja	2	5	E	46,18	18,90	46,18	18,90
58H	1999	Szeremle	2000	Baja	2	9	NE	46,18	18,52	46,18	18,90
594	1999	Decs	2000	Baja	2	15	SE	46,30	18,91	46,18	18,90
5002	2001	Baja	2002	Baja	2	5	W	46,18	18,91	46,18	18,84
5009	2001	Decs	2003	Baja	3	15	SE	46,30	18,91	46,18	18,90
501R	2002	Pörböly	2003	Rétszilas	2	75	NNW	46,18	18,87	46,83	18,65
502A	2001	Lábod	2003	Pörböly	3	108	E	46,18	17,47	46,18	18,88
504W	2002	Hercegkút	2004	Naszály	3	254	SWW	48,33	21,51	47,69	18,26
505U	2003	Homorúd	2004	Baja	2	30	NNE	45,58	18,49	46,18	18,90
505U	2003	Homorúd	2005	Baja	3	30	NNE	45,58	18,49	46,18	18,90
50HA	2004	Szőgye	2005	Aradac	2	340	SE	47,45	17,42	45,37	20,28
50J4	2006	Báta	2009	Sándorfalva	3	103	ENE	46,12	18,77	46,33	20,14
50JP	2005	Hercegszántó	2007	Szeremle	3	21	NNW	45,94	18,89	46,18	18,52
50L0	2005	Decs	2007	Szeremle	3	18	S	46,30	18,91	46,18	18,52
50L4	2005	Kölked	2006	Baja	2	32	NNE	45,91	18,74	46,18	18,90
50LC	2005	Szekszárd	2006	Pörböly	2	19	SSE	46,20	18,51	46,18	18,88
50LC	2005	Szekszárd	2007	Szeremle	3	26	SSE	46,20	18,51	46,18	18,52
50LJ	2005	Szekszárd	2006	Decs	2	9	SE	46,20	18,51	46,18	18,46
50LU	2009	Kölked	2010	Baja	2	32	NNE	45,91	18,74	46,18	18,90
50P9	2007	Kemence	2008	Biharugra	2	235	SE	48,02	18,89	46,96	21,60
50P9	2007	Kemence	2009	Smeerling	3	996	NW	48,02	18,89	53,02	7,07
50T4	2006	Ócsa	2008	Akasztó	3	67	S	47,29	19,23	46,69	19,20
50T5	2006	Ócsa	2008	Békés	3	155	SE	47,29	19,23	46,67	21,04
50TV	2006	Vaskút	2007	Gara	2	14	S	46,15	19,00	46,03	19,00
50UU	2007	Hercegszántó	2008	Nagybaracska	2	14	N	45,94	18,89	46,06	18,89
50UU	2007	Hercegszántó	2009	Gara	3	14	NE	45,94	18,89	46,03	19,00
50UV	2007	Hercegszántó	2009	Mohács	3	12	NWW	45,94	18,89	45,97	18,74
50WA	2007	Kisköre	2008	Kopacevo	2	247	SSW	47,52	20,59	45,60	18,79
50X1	2007	Szekszárd	2009	Baja	3	20	SSE	46,20	18,51	46,18	18,90
50X6	2007	Báta	2008	Nagybaracska	2	12	SSE	46,12	18,77	46,06	18,89
50X6	2007	Báta	2009	Sükösd	3	19	NNE	46,12	18,77	46,31	18,93
50XL	2007	Mohács	2009	Mohács	3	2	E	45,97	18,74	45,97	18,74
50XN	2007	Mohács	2008	Kopacevo	2	48	SSE	45,97	18,74	45,60	18,79
50XP	2007	Dunafalva	2009	Baja	3	12	NNE	46,08	18,80	46,18	18,90
6022	2003	Doubice	2004	Biharugra	2	678	SE	50,88	14,47	46,96	21,62
6022	2003	Doubice	2005	Kopacevo	3	668	SSE	50,88	14,47	45,60	18,79
6061	2003	Stary Rokytnik	2003	Biharugra	3	573	SE	50,53	15,94	46,96	21,62
6068	2001	Hr. Stepanice	2003	Baja	3	556	SSE	50,64	15,54	46,18	18,90
7017	2006	Paidre	2008	Kenderes	3	1246	SSW	57,91	26,44	47,25	20,67
0AJM	2002	Mezotne	2004	Kisköre	3	1024	SSW	56,44	23,98	47,52	20,59
1A22	2005	Parzeczew	2006	Szekszárd	2	617	S	51,94	19,20	46,20	18,51
1L64	2005	Restarzew	2006	Báta	2	586	S	51,39	19,09	46,12	18,77
60T4	2005	Dolni Olesnice	2007	Szeremle	3	539	SSE	50,52	15,71	46,18	18,52
610J	2005	Pardubice	2007	Rétszilas	3	413	SE	50,03	15,82	46,83	18,65
613T	2004	Praha	2006	Baja	3	546	SE	50,08	14,68	46,18	18,90
61LL	2006	Horni Branna	2007	Kunhegyes	2	512	SE	50,60	15,56	47,35	20,60
6MN	1999	Bystrice	2000	Baja	2	382	SSE	49,63	18,68	46,18	18,90
6RR	2002	Studnice	2003	Rétszilas	2	441	SSE	50,42	16,08	46,83	18,65
6XJ	2002	Dobris	2003	Baja	2	530	SE	49,77	14,18	46,18	18,90
82R	1996	Vitanová	1997	Túrkeve	2	259	SSE	49,34	19,71	47,10	20,77
8CU	2003	Malé Leváre	2005	Kisújszállás	3	314	ESE	48,50	16,92	47,19	20,75
C65	1999	Willerzie	2000	Bácsalmás	2	1153	ESE	49,97	4,84	46,08	19,35
X025	2006	Apatin	2007	Baja	2	59	N	45,66	18,94	46,18	18,90
X025	2006	Apatin	2008	Baja	3	59	N	45,66	18,94	46,18	18,90

Annex 4. Hungarian-related observations of Adults in breeding range.

Ring no.	Ringed		Observed					co-ordinates			
(CR)	Year	Place	Year	Place	Age (cy)	Distance (km)	Direction	ringing lat	ringing lon	observation lat	observation lon
50V	1995	Decs	2000	Baja	6	15	SE	46,18	18,46	46,18	18,90
541	1996	Homorúd	2003	Kopacevo	8	43	S	45,58	18,49	45,60	18,79
541	1996	Homorúd	2004	Kopacevo	9	43	S	45,58	18,49	45,60	18,79
541	1996	Homorúd	2005	Kopacevo	10	43	S	45,58	18,49	45,60	18,79
563	1998	Baja	2004	Kopacevo	7	68	S	45,58	18,49	45,60	18,79
563	1998	Baja	2005	Kopacevo	8	68	S	45,58	18,49	45,60	18,79
56C	1997	Homorúd	2000	Baja	4	30	NNE	45,58	18,49	46,18	18,90
56C	1997	Homorúd	2002	Baja	6	30	NNE	45,58	18,49	46,18	18,90
56C	1997	Homorúd	2006	Baja	10	30	NNE	45,58	18,49	46,18	18,90
56C	1997	Homorúd	2007	Baja	11	30	NNE	45,58	18,49	46,18	18,90
583	1999	Baja	2002	Baja	4	5	E	46,18	18,90	46,18	18,90
58U	1999	Szekszárd	2006	Szekszárd	8	2	E	46,20	18,51	46,20	18,51
58U	1999	Szekszárd	2007	Őcsény	9	7	SEE	46,20	18,51	46,30	18,90
500M	2001	Várdaróc	2004	Kopacevo	4	3	SE	45,62	18,77	45,60	18,79
5010	2001	Szekszárd	2005	Kopacevo	5	88	SSE	46,34	18,83	45,60	18,79
5010	2001	Szekszárd	2007	Darda	7	80	S	46,34	18,83	45,62	18,70
502T	2001	Zselicszentpál	2008	Kopacevo	8	115	SE	46,30	17,84	45,60	18,79
5046	2001	Sárospatak	2006	Kunhegyes	6	127	SW	48,31	21,58	47,35	20,60
505U	2003	Homorúd	2009	Nagybaracska	7	15	NNE	45,58	18,49	46,06	18,89
508R	2004	Hont	2008	Kenderes	5	154	SE	48,05	18,98	47,25	20,67
50CT	2004	Baja	2008	Kenderes	5	182	NE	46,18	18,91	47,25	20,67
50L0	2005	Decs	2008	Baja	4	15	SE	46,30	18,91	46,18	18,90
50L4	2005	Kölked	2008	Nagybaracska	4	20	NE	45,91	18,74	46,06	18,89
50L4	2005	Kölked	2009	Nagybaracska	5	20	NE	45,91	18,74	46,06	18,89
50P9	2007	Kemence	2010	Berneray	4	2040	NW	48,02	18,89	57,71	-7,15
X011	2004	Apatin	2007	Naszály	4	233	NNW	45,66	18,94	47,69	18,26
X025	2006	Apatin	2010	Baja	5	59	N	45,66	18,94	46,18	18,90

Annex 5. Hungarian-related observations of Adults on nest.

Ring no.	Ringed		Observed					co-ordinates			
(CR)	Year	Place	Year	Place	Age (cy)	Distance (km)	Direction	ringing lat	ringing lon	observation lat	observation lon
52L	1996	Szenta	2005	Újvárfalva	10	37	NE	46,15	17,12	46,26	17,34
563	1998	Baja	2006	Bátsziget	9	68	S	45,58	18,49	45,33	18,48
56C	1997	Homorúd	2003	Baja	7	30	NNE	45,58	18,49	46,18	18,90
58U	1999	Szekszárd	2008	Decs	10	11	SE	46,20	18,51	46,30	18,91
505V	2003	Homorúd	2008	Baja	6	30	NNE	45,58	18,49	46,18	18,90
50XH	2007	Tarpa	2010	Kisújszállás	4	165	SW	48,10	22,53	47,19	20,75
X01U	2005	Apatin	2009	Ipolytölgyes	5	254	N	45,66	18,94	47,87	18,81
1P58	2003	Sosnie	2010	Kondó	8	421	SSE	51,47	17,63	48,18	20,63

Annex 6. A typical Black Stork feeding place on aerial photo in Gemenc, Hungary (by Keve Gábor)

Annex 7. A typical Black Stork feeding place closeup in Gemenc, Hungary (by Mórocz Attila)

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Annex 10. Aerial photo of typical Jordan valley fishponds, Israel (by Joosep Tuvi)

Annex 11. Closeup typical feeding place in a Jordan valley fishpond, Israel (by Renno Nellis)

Annex 12. Peer-rewiewed, indexed publications on which the thesis work is based on

Tamás E.A. 2011: Longevity and survival of the black stork Ciconia nigra based on ring recoveries. Biologia 66 (5): 912-915.

Tamás E.A., Kalocsa B. 2006: The diet of young's and feeding places of Black Storks Ciconia nigra in Gemenc. Biota 7 (1-2): 103-108.

Tamás E.A., Kalocsa B., Strazds M. 2006: Foreword. Biota 7 (1-2): 5-6.

Tamás E.A., Zellei L., Sziebert J., Szlavik L., Kalocsa B. 2006: Determination of status, processes and targets in the planning of the nature protection aspect rehabilitation of the southern Hungarian Danube floodplains. Geophysical Research Abstracts 8: 10267.

Tamás E.A., Kalocsa B. 2005: Management-related problems of floodplain habitats for the Black stork (Ciconia nigra). Archiv für Hydrobiologie. Supplementband. Large rivers 15 (1-4): 483-490.

Kalocsa B., **Tamás E.** 2002: Adatok a fekete gólya (Ciconia nigra) táplálkozásához 1996-2002 között Magyarországon végzett vizsgálatok alapján. Aquila 107-108: 241-247. (in Hungarian with English abstract)

Kalocsa B., **Tamás E.A.** 2002: Forum: Comments on the short article Tucakov, M. (2002): A case of late breeding of the Black Stork Ciconia nigra in northwestern Voivodina (Serbia). Acrocephalus 23 (112): 97-98. Acrocephalus 23 (113): 114.

Kalocsa B., **Tamás E.A.** 2002: A fekete gólya (Ciconia nigra) állományának felmérése a gemenci erdőben - fészkelési szokások és költési eredményesség (1992-2000). Aquila 107-108: 215-223. (in Hungarian with English abstract)

Kalocsa B., **Tamás E.A.** 2002: Fekete gólyák (Ciconia nigra) nemzetközi színes gyűrűzési programja és ennek magyarországi vonatkozásai (1994-2000). Aquila 107-108: 249-257. (in Hungarian with English abstract)

Kalocsa B., **Tamás E.A.** 2002: Fekete gólyák (Ciconia nigra) számára készített műfészkekkel kapcsolatos tapasztalatok Gemencben (1996-2000). Aquila 107-108: 259-263. (in Hungarian with English abstract)

Kalocsa B., **Tamás E.A.** 2002: Status of the Black stork (Ciconia nigra) in Hungary in 2000. Aquila 107-108: 207-213.

Kalocsa B., **Tamás E.A.** 2004: Addendum to the diet of the Black Stork in the Gemenc Region of the Danube-Drava National Park, Hungary 1996-2000. AVES 40 (1-4): 75-83.

Kalocsa B., **Tamás E.A.** 2004: "Black Stork (Ciconia nigra) Colour Ringing and Recoveries in Hungary, 1994-2000. AVES 40 (1-4): 109-117.

Kalocsa B., **Tamás E.A.** 2004: "Conservation measures for the Black Stork in Hungary, particularly in the Gemenc region of the Danube-Drava National Park, 1996-2000. AVES 40 (1-4): 222-227.

Kalocsa B., **Tamás E.A.** 2004: Status of the Black Stork (Ciconia nigra) in Hungary in the year 2000. AVES 40 (1-4): 45-49.

Kalocsa B., **Tamás E.A.** 2006: An evaluation of colour ringing recoveries of Black Storks Ciconia nigra related to Hungary, Biota 7 (1-2): 51-58.

Kalocsa B., **Tamás E.A.** 2006: Analysis of the nesting data of Black Storks Ciconia nigra in the Gemenc region of the Danube-Drava National Park (1992-2003), Biota 7 (1-2): 47-50.

Tucakov M., Kalocsa B., Mikuska T., **Tamás E.A.**, Žuljevic A., Erg B., Deme T. 2006: The Black Stork Ciconia nigra between the Sió channel and the Drava river in the central Danube floodplain: transboundary monitoring and protection plan, Biota 7 (1-2): 109-118.

Goda L., Kalocsa B., **Tamás E.A.** 2007: River bed erosion on the Hungarian section of the Danube. Journal of Environmental Science for Sustainable Society 1: 47-54.

Annex 13: Oral and poster presentations related to the subject of the thesis work

II. International Conference on the Black stork, Trujillo, Spain, 1996

1. Kalocsa B., **Tamás E.A.**: Status of the Black stork in Hungary, (oral)
2. Kalocsa B., **Tamás E.A.**: Nesting of the Black storks in the Gemenc floodplain forest, (oral)

I. Hungarian Conference on the Black Stork, Érsekcsanád, Hungary, 2000.

3. Kalocsa B., **Tamás E.A.**: A fekete gólya (Ciconia nigra) állományfelmérése, fészkelési szokásai és költési eredményessége a gemenci erdőben, 1992-2000. (oral)
4. Kalocsa B., **Tamás E.A.**: Adatok a fekete gólya (Ciconia nigra) táplálkozásához, 1996-2000. (oral)
5. Kalocsa B., **Tamás E.A.**: Fekete gólyák (Ciconia nigra) számára készített mûfészkekkel kapcsolatos tapasztalatok Gemencben, 1996-2000. (oral)
6. Kalocsa B., **Tamás E.A.**: A nemzetközi fekete gólya (Ciconia nigra) színes gyűrűzési program és annak magyarországi vonatkozásai, 1994-2000 (oral)
7. Kalocsa B., **Tamás E.A.**: Status of the Black stork (Ciconia nigra) in Hungary in 2000. (oral)

III. International Conference on the Black stork, Forneau Saint-Michel, Belgium, 2001.

8. Kalocsa B., **Tamás E.A.**: Status of the Black Stork (Ciconia nigra) in Hungary in 2000. (oral)
9. Kalocsa B., **Tamás E.A.**: Conservation Measures of the Black Stork (Ciconia nigra) in Hungary, particularly in the Gemenc Region of the Danube, Drava National Park, 1996-2000. (oral)
10. Kalocsa B., **Tamás E.A.**: Black Stork (Ciconia nigra) Colour Ringing and Recoveries in Hungary, 1994-2000. (oral)
11. Kalocsa B., **Tamás E.A.**: Addendum to the diet of the Black stork (Ciconia nigra) in the Gemenc Region of the Danube, Drava National Park, Hungary 1996-2000. (oral)

I. Hungarian Conservation Biology Conference, Sopron, Hungary, 2002.

12. Kalocsa B., **Tamás E.A.**: A fekete gólya védelme (poster)
13. **Tamás E.A.**, Kalocsa B.: A fekete gólya hullámtéri élőhelyeinek problémái (poster)
14. Kalocsa B., **Tamás E.A.**: Vizes élőhelyekkel kapcsolatos problémák az alsó Duna-völgyben (oral)

„Life in the Danube Floodplains” scientific congress, Érsekcsanád, Hungary, 2003.

15. Kalocsa B., **Tamás E.A.** Fekete gólya színes gyűrűzési program és magyar vonatkozású eredményei (oral)
16. Kalocsa B., **Tamás E.A.** Fekete gólya állománykövetése és gyakorlati védelmi intézkedések a DDNP Gemenci Tájegységében (oral)

Conference on Lowlad River Restoration Wageningen, the Netherlands, 2003

17. **Tamás E.A.**, Kalocsa B.: Management-related problems of floodplain habitats of the Black stork (Ciconia nigra), (poster)

4th International Conference on the Black stork, Dávod-Püspökpuszta, Hungary, 2004.

18. Kalocsa B., **Tamás E.A.:** The evaluation of colour ringing recoveries related to Hungary (oral)
19. Kalocsa B., **Tamás E.A.**: Analysis of the nesting data of Black storks and protective measures in the Gemenc region of the Danube-Drava National Park (oral)
20. **Tamás E.A.,** Kalocsa B.: The diet and feeding places of Black storks in Gemenc (oral)
21. Tucakov M., Kalocsa B., **Tamás E.A.**, Zuljevic A., Mikuska T., Deme T., Erg B.: The Black Stork between the Sió and the Drava rivers in the central Danube floodplain: transboundary monitoring and protection plan, (oral)
22. Kalocsa B., **Tamás E.A.**: The status of the Black stork in Hungary in 2004. (poster)
23. Kalocsa B., **Tamás E.A.**, Zuljevic A., Tucakov M., Mikuska T., Deme T. and Erg B.: Contemporary distribution of Black storks and White-tailed Eagles in the Central Danubian floodplain, (poster)

6th Scientific Meeting of MME BirdLife Hungary, Debrecen, Hungary, 2004

24. Kalocsa B., **Tamás E.A.**, A nemzetközi fekete gólya színes gyűrűzési program és magyar vonatkozású eredményei (oral)
25. **Tamás E.A.**, Kalocsa B., Egy hullámtéri vizes élőhely állapotjellemzése madárfauna-monitoring alapján (oral)
26. Kalocsa B., **Tamás E.A.**: The status of the Black stork in Hungary in 2004. (poster)
27. Kalocsa B., **Tamás E.A.**, Zuljevic A., Tucakov M., Mikuska T., Deme T. and Erg B.: Contemporary distribution of Black storks and White-tailed Eagles int he Central Danubian floodplain, (poster)

European Geosciences Union General Assembly, Vienna, Austria, 2005

28. **Tamás E.A.**, Kalocsa B.: The importance of bird fauna monitoring in the hydro-ecological evaluation of wetland status (poster)

EU Enlargement Conference, Veliko Tarnovo, Bulgaria, 2005.

29. **Tamás E.A.**: The Central Danubian Floodplains Working Group, a tripartite NGO initiative for sustainable nature protection across the border of the EU (oral)

„Life in the Danube Floodplains" scientific congress, Pörböly, Hungary, 2005.

30. Kalocsa B., **Tamás E.A.**: Fekete gólya fészek webkamerás megfig.yelésének tapasztalatai (oral)
31. Kalocsa B., **Tamás E.A.**: Összefoglaló a fekete gólya színes gyűrűzés legfrissebb eredményeiről (oral)
32. Kalocsa B., **Tamás E.A.**: Fekete gólyák műholdas követése: a „Flying over Natura 2000" projekt előzetes eredményei (oral)
33. **Tamás E.A.**, Kalocsa B.: Ökológiai monitoring értékelése a rekonstrukciós beavatkozások és az ártéri víztestek célállapota szempontjából (oral)

III. Hungarian Conservation Biology Conference, Eger, Hungary, 2005.

34. **Tamás E.A.**, Kalocsa B.: Hullámtéri vizes élőhelyek célállapot-meghatározásának kérdései a Nyéki holt-Duna példáján (poster)

European Geosciences Union General Assembly, Vienna, Austria, 2006

35. **Tamás E.A.**, Zellei L., Sziebert J. Szlávik L., Kalocsa B.: Determination of status, processes and targets in the planning of the nature protection aspect rehabilitation of the southern Hungarian Danube floodplains (poster)

The SIL Limnology & Waterbirds Conference, Eger, Hungary 2006.

36. **Tamás E.A.**, Kalocsa B.: The Importance of Dynamic Temporary Waterbodies for Waterbirds, The Case of the Black Stork (Ciconia nigra) and the Floodplain (oral)

9th International Symposium on Environmental Issues of World Major River Basin Okayama, Japan, 2007.

37. Goda L., Kalocsa B., **Tamás E.A.**: River Bed Erosion on the Hungarian Section of the Danube (oral)

II. Hungarian Conference on the Black Stork, Pörböly, Hungary, 2007.

38. Kalocsa B., **Tamás E.A.**: A fekete gólya színes gyűrűzési program legfrissebb eredményei (oral)
39. **Tamás E.A.**, Kalocsa B.: Fekete gólyák műholdas követése (oral)
40. Kalocsa B., **Tamás E.A.**: Fekete gólya fészek webkamerás megfig.yelése (oral)
41. **Tamás E.A.**, Kalocsa B.: A fekete gólyák tápláléka és táplálkozóhelye az alsó Duna-völgyben (oral)
42. Kalocsa B., **Tamás E.A.**, Mórocz A.: Gemenci területi beszámoló (oral)
43. Mikuska T., Kalocsa B., **Tamás E.A.**: Status of the Black stork population in Kopacki rit Nature Park (Croatia) 2002-2006. (oral)

„Life in the Danube Floodplains" scientific congress Pörböly, Hungary, 2007.

44. **Tamás E.A.** és Kalocsa B.: A Duna vízszintsüllyedésével kapcsolatos vizsgálatok legfrissebb eredménye (oral)

Harmonizing nature protection management practices along transboundary protected areas Tikves, Croatia, 2007.

45. **Tamás E.A.**: Hydrological background, problems and possibilities in the water supply of floodplain wetlands in the central Danube-Drava region (oral)

Danube, **Lifeline of Europe, International Danube Region Conference Ulm, Germany, 2007.**

46. **Tamás E.A.: Wetlands in the Central Danube Floodplain, Values, Problems and Possibilities** (oral)

7th Scientific Meeting of MME BirdLife Hungary, Baja, Hungary, 2008.

47. Kalocsa B., **Tamás E.A.**: A nemzetközi fekete gólya vonuláskutatás 15 éve, a program magyarországi vonatkozásai (oral)

V. International Conference on the Black Stork, Uzlina, Romania, 2008.

48. **Tamás E.A.**, Kalocsa B.: Results and experiences of remote Black stork nest observation in Hungary, 2005-2007 (oral)

49. Kalocsa B., **Tamás E.A.**: Newest results of Black stork colour ringing and satellite telemetry in Hungary (2004-2007) (oral)

50. Kalocsa B., **Tamás E.A.**: The Black Stork in Hungary, 2004-2007. (oral)

3rd International Eurasian Ornithology Congress, Lesvos, Greece, 2010.

51. **Tamás E.A.**, Kalocsa B.: The migration of Eastern European Black Storks (*Ciconia nigra*) through Turkey and Israel (oral)

8th Conference of the European Ornithologists' Union, Riga, Latvia, 2011.

52. **Tamás E.A.,** van den Bossche W., Rohde C., Kalocsa B.: Importance and evaluation of the International Black Stork colour ringing programme (oral)