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Increase of the Population of the Eastern Imperial Eagle (*Aquila heliaca*) in Bulgaria

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Abstract: Since 2000, the systematic conservation activities have resulted in an improved status of the Bulgarian population of Eastern Imperial Eagle (*Aquila heliaca* Savigny 1809). The population is estimated at 25-30 pairs. In the period 2001-2009, 13 newly occupied and 3 reoccupied territories were recorded. In 2009 the number of known occupied territories increased to 20. Occupied territories, breeding pairs, and population breeding parameters were recorded on annual basis. The recorded data included adult survival rate and age structure of the breeding population. The average values of the breeding parameters of the population for the period 2000-2009 were as follows: productivity 0.90±0.23; breeding success 1.01±0.26; fledglings success 1.56±0.25; and success rate 64.45% ±11.52. Nest guarding, rehabilitation of injured birds and subsequent release, "moving of pairs", supplementary feeding, construction of artificial nests, increase of the awareness among local communities and authorities, nesting habitat management, ringing of nestlings, satellite and radio tracking, and purchase of land around the nests have been implemented for the conservation of the species. The main threats are: habitat loss, disturbance, shooting, poisoning, and natural disasters.

Key words: population growth, Eastern Imperial Eagle, conservation, breeding parameters, Bulgaria

Introduction

The Eastern Imperial Eagle is classified as vulnerable on a global scale (IUCN 2009) and threatened at European level (Tucker, Heath 1994). The species is listed in Annex I of the Birds Directive, Appendix I of CITES, and Appendix II of the Bonn and Bern Conventions. At national level, the species is included in Annexes II and III of the Biological Diversity Act, as well as in the Red Data Book of Bulgaria (in press).

Increased numbers of Eastern Imperial Eagles were reported in various parts of the species' range (Karyakin 1998, 1999, 2008, Karyakin *et al*. 2008, Belik, Galushin 1999, Belik 2008, Bagyura *et al*. 2002, Horvath *et al*. 2002, Horvath *et al*. 2011, Danko *et al*. 2011, Wichmann 2011, Vetrov, Milobog 2008).

At the end of the 19th and the beginning of the 20th centuries the species was abundant and widespread throughout the country (Farman 1869, Elwes, Buckley 1870, Radakoff 1879, Alleon 1886, Hristovich 1890, Reiser 1894, Leverkuhn 1907). The subsequent period of significant decline of the Eastern Imperial Eagle population turned the species into one of Bulgaria's rarest birds (Patev 1950). Michev, Petrov (1979) reported the occur-

rence of the species in 19 localities in the country for the period 1970-1978. Between 1980 and 1993 the species was reported in 35 localities; however, there were only nine cases of confirmed breeding (Petrov *et al*. 1996). For that period the population was estimated at 15-20 breeding pairs. With the intensified ornithological research after 1990 and the consistent studying of the Eastern Imperial Eagle distribution, threats, and numbers during the period 1994-2002 (Stoychev 1997, Petrov 1999), the number of known pairs reached 13. For the same period the population was estimated at 20-25 pairs (Stoychev *et al*. 2004) and 30-40 pairs (Nankinov *et al*. 2004).

If a population of large and long-lived raptors is to grow, it must have high survival rates of adult and subadult individuals, presence of floaters, good breeding success, availability of suitable habitats comprising breeding and foraging sites, age of first reproduction and maturity, and mitigation of major limiting factors (Newton 1979, Katzner *et al*. 2006).

The systematic research implemented over the past decade revealed an obvious increase in the Eastern Imperial Eagle population in Bulgaria. Newly occupied territories were recorded in hilly and lowland areas of the Sakar and the Western Strandja Mountains as well as the Tundja river valley, while loss of territories was recorded in the mountain areas (Hristov, Stoynov 2002, Demerdzhiev 2004, Demerdzhiev manuscript, Angelov 2009). The species' population is estimated at 25-30 pairs, as 20 breeding territories occupied by pairs were known in 2009.

Material and Methods

Field surveys

Since 2000, the research and conservation activities implemented by the Bulgarian Society for the Protection of Birds and Green Balkans NGO have improved the status of the Eastern Imperial Eagle in Bulgaria. The intensity of the monitoring and the quality of the gathered data were improved, thus identifying the dynamics of the species' population. The systematic regional studies carried out by the experts of these two organizations every year minimized the risk of leaving territories occupied by eagles undetected. This method makes it possible to record the actual situation of the population (Newton 1979).

One hundred and twenty-five 10x10 km UTM grid squares in the areas harboring breeding Eastern Imperial Eagles were inspected every year or once every two years searching for newly occupied territories. In addition, 150 UTM grid squares, where the species was recorded during the breeding season with varying degrees of reliability of breeding, or which represent suitable habitats, were visited at least once during the period 2000-2009. The inspections involved transect methods used mainly along river valleys or streams, or examination of high and/or single trees in open habitats. Another method used during the inspections was observations from view point (Bibby *et al*. 1999, Andersen 2007). The studies were carried out mainly in the period February-May, when trees were not in full leaf and the nests could easily be seen. Observations were also carried out in June and July, monitoring the eagles' behavior in order to locate their nests. The degree of certainty of breeding is according to Hagemejer, Blair 1997. During the breeding period (February-August) monitoring of occupied nests was carried out twice or three times a month. During the autumn and winter period the breeding territory of each pair was visited at least once a month. Risky nests situated near arable lands or roads were guarded during the breeding season by volunteers of the two organizations to increase the breeding success. In cases when a pair bred in an unsuitable place, where the chances of raising chicks were poor, the access to the nest was hindered so that birds could not alight on the nest.

Data analyses

Occupied territories, breeding pairs, and population breeding parameters were recorded on an annual basis. The recorded data included adult survival rate and age structure of the breeding population. The estimates of the annual mortality of breeders (adult and subadult) were based on the replacement of birds in pairs. The new partner is considered to replace a dead mate. However, this assessment is not an absolute value due to the fact that sometimes it is impossible to record the replacement of a partner from the pair by an individual of the same age (Ferrer 2001). Breeding Eastern Imperial Eagles found dead during the study period were also reported. The identification of plumage is according to Forsman (2005). Considering the different opinions regarding the

number of plumages of the Imperial Eagle (Clark 2004, Forsman 2005), and the vaguely determined marks of the last, sixth plumage by Forsman (2005), the birds at that age (6th calendar year) were considered adults. The pairs were divided into three categories: adult – consisting of two individuals in adult plumage; mixed – consisting of an individual in immature plumage (second-fifth) and an adult partner (from sixth plumage up); and immature – consisting of two individuals in immature plumage.

We estimated the productivity (number of fledglings per occupied territory), the breeding success (number of fledglings per breeding pair), and the fledglings success (number of fledglings per successful pair) for the period 2000-2009, including 148 breeding attempts. For the period 2000-2009, we also estimated the value of the success rate (frequency of breeding attempts with at least one fledged chick), including 132 breeding attempts.

Statistic processing of data was carried out using the program Statistica for Windows, Release 7.0 (STATSOFT Inc. 1984-2004). The comparison of the breeding parameters was based on the parametric One-way ANOVA analysis with *post-hoc* LSD-test. In the analysis, the breeding pairs were presented in groups based on the geographical regions, corresponding almost entirely to their habitat preferences. The two pairs in Sredna Gora and the only pair in the Eastern Rhodopes were united in one group (mountain-wooded region) due to the similarity in their habitats (Demerdzhiev manuscript). The data was analyzed for normal distribution through the Shapiro-Wilk test (SHAPIRO *et al*., 1968). Results with $p<0.05$ [α=5%] were considered significant.

Results

Breeding distribution and habitat performance

At the end of the 19th and the beginning of the 20th centuries the species was reported by many authors as abundant and wide-spread (Farman 1869, Elwes, Buckley 1870, Radakoff 1879, Alleon 1886, Hristovich 1890, Reiser 1894, Leverkuhn 1907). During the following decades the Eastern Imperial Eagle population in Bulgaria suffered severe decline, and by the end of 1970s there were only 3 certain localities of this species situated in mountain areas of 400 m to 1.200 m a.s.l. (Michev, Petrov 1979). The gradual recovery of the Imperial Eagle population in Bulgaria began after the socio-economic changes and the adoption of extensive agricultural practices in the 1990s. The species is distributed mainly in SE Bulgaria. Since the 1960s, there has been no confirmed breeding of this species in northern Bulgaria. In the period 2000-2009 there were 25 known breeding territories occupied over the years by 24 pairs[1] (Fig. 1).

The area with the greatest number of nests is the Sakar Mountains and the lower reaches of the Maritsa River, harboring 11 known nests. The habitat of the pairs (n = 8) breeding in the Southern Sakar Mountains is represented by some 40% of abandoned areas, grasslands, significant overgrowth of scrubs and small trees, midsized pastures and forests, 50-250 m a.s.l.. In the Northern Sakar Mountains, the three breeding pairs are found in habitats characterized by some 40% of abandoned areas or arable lands, significant representation of pastures and vineyards and some scrub patches, 100-250 m a.s.l.. The area with the second greatest number of nests is the neighboring hilly region of the Dervent Heights – Western Strandzha, where 5 confirmed breeding pairs were recorded. The terrains used by Imperial Eagles breeding in this area are characterized by more than 50 % of abandoned areas, insignificant representation of pastures and grasslands, and a low percentage of forest coverage, 250-280 m a.s.l. To the north of these pairs, in the Tundja river valley, five breeding pairs are recorded, situated in lowlands or low hilly treeless areas, between 130-250 m a.s.l. The habitats consist of about 70% of arable lands and abandoned areas, small pastures and grasslands, agricultural crops, and insignificant representation of tree-bush vegetation. The pairs breeding in these regions, constituting 87.5% of all known pairs, could be considered as a subpopulation of the species (Stoychev *et al.* 2004). A breeding group, consisting of only 2 breeding pairs, was located in the Sredna Gora Mountains. There was one breeding territory known in the Eastern Rhodope Mountains, probably remaining from a disappearing breeding group of Imperial Eagles (Hristov, Stoynov 2002,

[1] One of the breeding pairs occupied two different territories over the years.

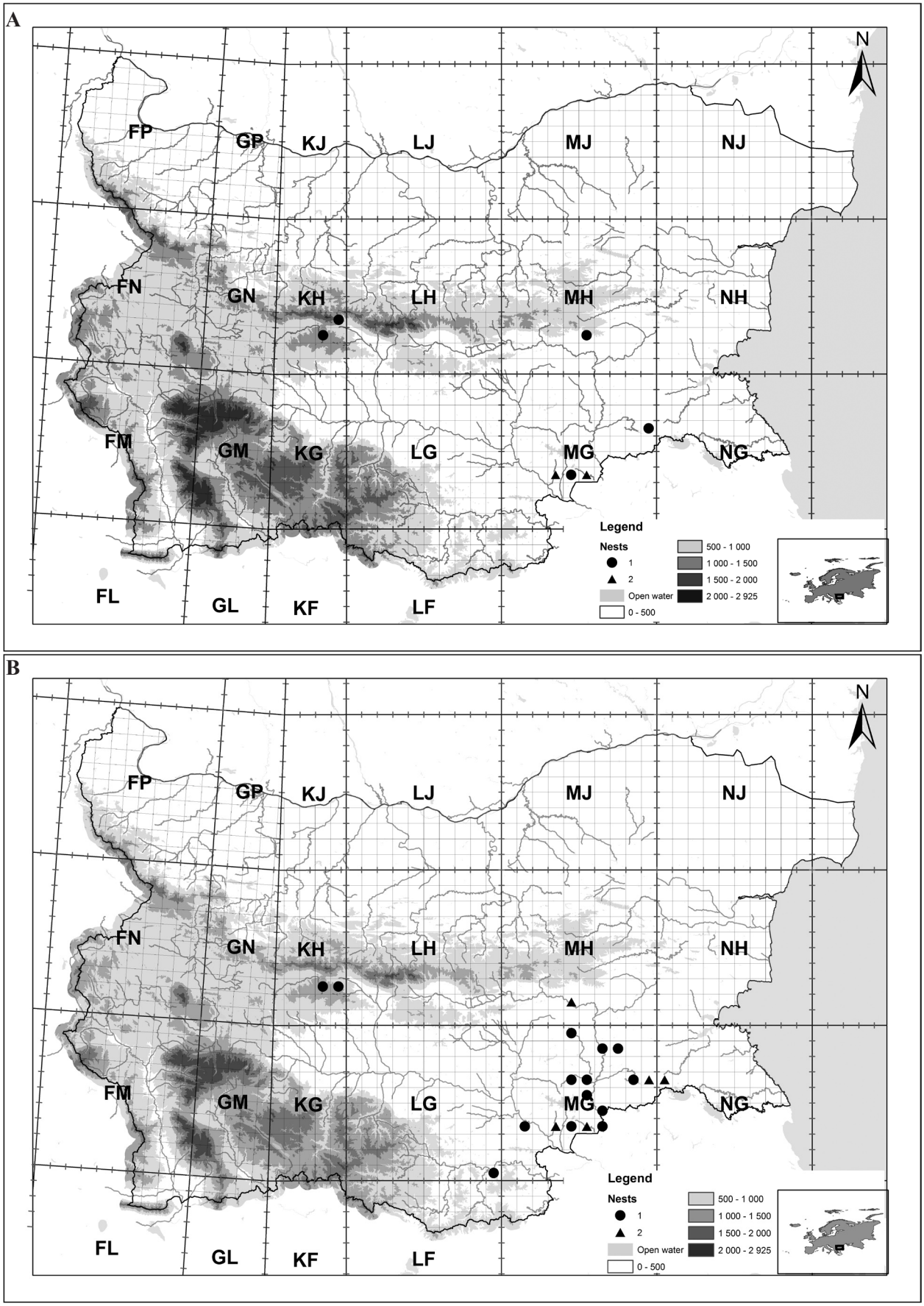

Fig. 1. Distribution of the occupied breeding territories in the periods 1990-1999 (A) and 2000-2009 (B); ● – one nest; ▲ – two nests

Demerdzhiev 2004, Demerdzhiev manuscript). The Imperial Eagles breeding in these two mountains belong to the mountain-wooded habitat, characterized by 30% to 70% of forests, agricultural crops, and low representation of abandoned areas and pastures, 330-1.100 m a.s.l.

There were also observations of single birds and pairs in northern Bulgaria, the Western Rhodopes, and the Western Balkan Mountains, but breeding was not proven (Stoychev *et al*. 2007). For the period 2000-2009, there were 24 cases of certain, three of probable, and six of possible breeding.

Based on this data, the Bulgarian population for the period 2002-2009 was estimated at 25-30 breeding pairs.

Occupation of new breeding territories by Imperial Eagles was recorded after 2001. The number of territories occupied by pairs increased from 8 to 20 between 2000 and 2009 (Fig. 2).

Breeding parameters

During the period 2000-2009, 63 different territorial individuals, of which 13 replacements and 2 discovered dead breeders, were recorded in 25 occupied territories. In two other cases, the replacement of a partner was not related to a dead mate, because it was recorded that the newcomer had displaced the previous breeder (Demerdzhiev manuscript). These two cases were excluded from the mortality analysis.

Annual survival rate of breeders varied from 0.875 to 1. As a whole, the survival rate of breeders ±SD for the period 2000-2009 was 0.954±0.039. The survival rates of breeders were found to be not dependent on the sex of the bird. The annual mortality of breeders of the Imperial Eagle population in Bulgaria varied from 0 to 12.5%, i.e. an average of 4.56% ±3.92 for the study period.

Estimation of the mean value of productivity, breeding success, and fledglings success for the period 2000-2009, including 148 breeding attempts, is presented in Table 1.

In general, the average values of the breeding parameters of the Eastern Imperial Eagle population for the period 2000-2009 were as follows: Productivity (P) 0.90±0.23; Breeding Success (BS) 1.01±0.26; and Fledglings Success (FS) 1.56±0.25. The dynamics of the breeding parameters over the years was monitored as well (Fig. 3).

The lowest values of the breeding success were recorded in 2003, when the percentage of immature breeders was highest (Fig. 4). Maximum values of breeding success were recorded in 2005, 1.58.

The success rate varied from 44.4% to 80%, i.e. a mean value of 64.45% ±11.52.

Comparing the breeding parameters of Eastern Imperial Eagles breeding in different regions, statistically significant differences ($p<0.05$) were identified in productivity, breeding success, and fledglings

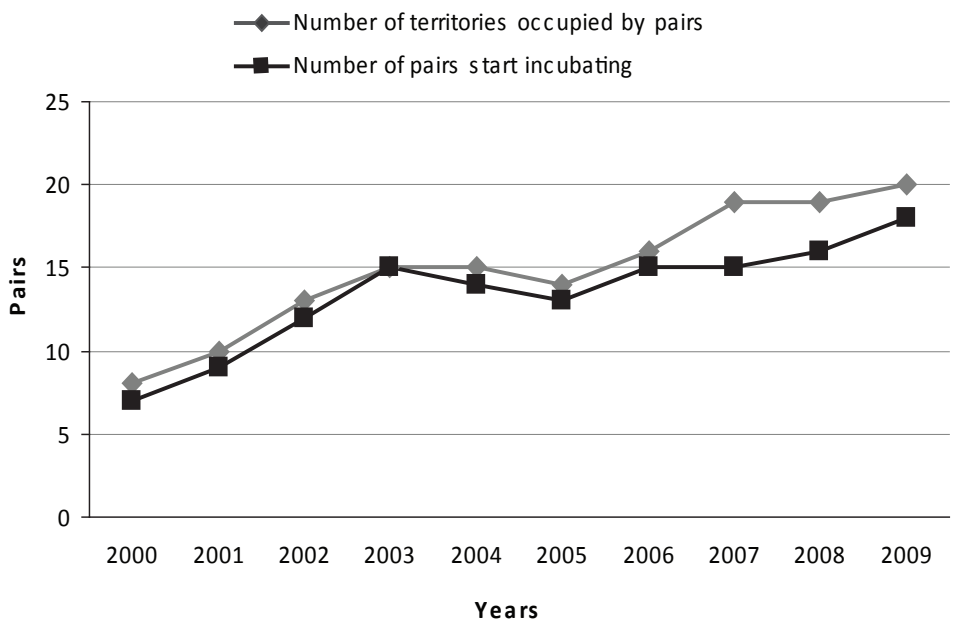

Fig. 2. Eastern Imperial Eagle population dynamics in Bulgaria

Table 1. Descriptive statistics of breeding parameters. P = Productivity; BS = Breeding Success; FS = Fledglings Success.

Variable	Valid N	Mean	Confidence -95,000%	Confidence +95,000%	Sum	Minimum	Maximum	Std.Dev.	Standard Error
P	10.00	0.90	0.73	1.06	8.99	0.67	1.46	0.23	0.07
BS	10.00	1.01	0.82	1.20	10.09	0.67	1.58	0.26	0.08
FS	10.00	1.56	1.38	1.73	15.56	1.11	2.00	0.25	0.08

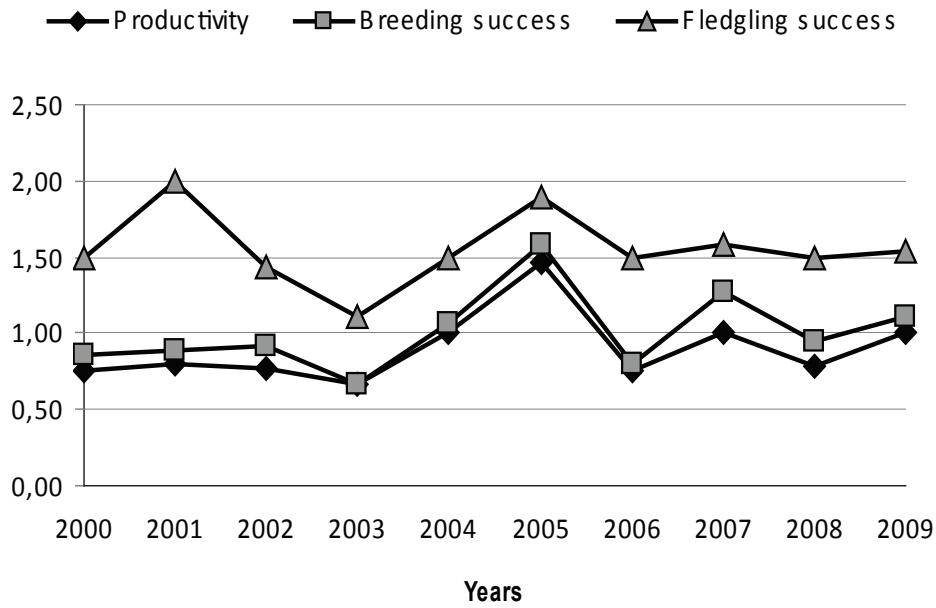

Fig. 3. Dynamics of the breeding parameters of the Eastern Imperial Eagle population in Bulgaria for the period 2000-2009

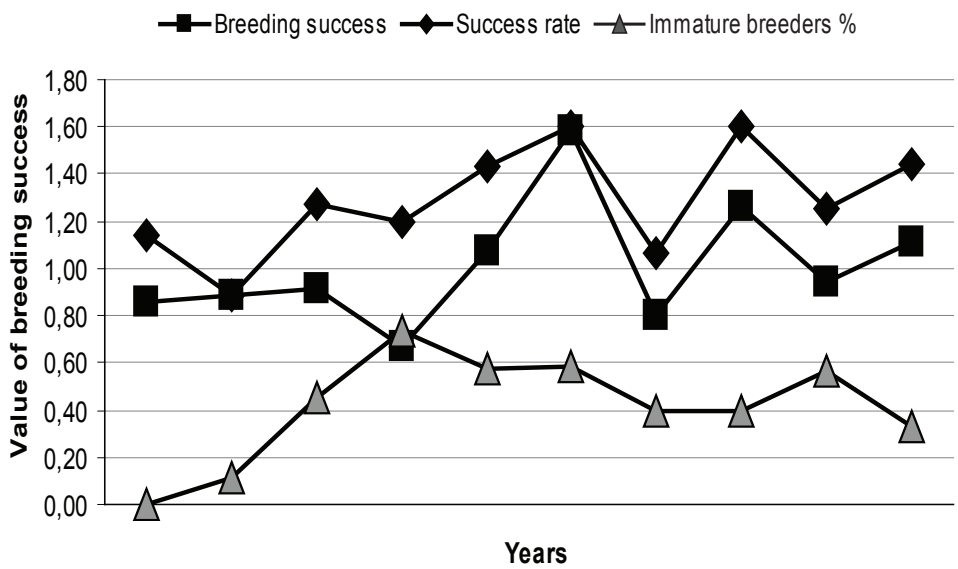

Fig. 4. Dependence of the breeding success on the percentage of immature breeders

Table 2. Comparison of productivity (PR), breeding success (BS), and fledglings success (FS) of pairs breeding in different regions: Sredna Gora/Eastern Rhodope (SG/ER), Dervent Heights/Western Strandzha (DH/WS), Southern Sakar (SS), Northern Sakar (NS), and the Tundja river valley (TV) (* statistically significant difference; ** statistically highly significant difference; *** statistically very highly significant difference). (One-way ANOVA analysis)

Productivity (PR)			
Region vs. region	N recorded cases	N recorded cases	P
SG/ER vs. DH/WS	22	24	0.001315**
SG/ER vs. SS	22	63	0.871861
SG/ER vs. NS	22	21	0.021694*
SG/ER vs. TV	22	18	0.542721
DH/WS vs. SS	24	63	0.001615**
DH/WS vs. NS	24	21	0.322986
DH/WS vs. TV	24	18	0.000283***
SS vs. NS	63	21	0.027464*
SS vs. TV	63	18	0.436376
NS vs. TV	21	18	0.005527**
Breeding Success (BS)			
Region vs. region	N recorded cases	N recorded cases	P
SG/ER vs. DH/WS	17	24	0.013225*
SG/ER vs. SS	17	56	0.925068
SG/ER vs. NS	17	21	0.111362
SG/ER vs. TV	17	14	0.410602
DH/WS vs. SS	24	56	0.008641**
DH/WS vs. NS	24	21	0.362624
DH/WS vs. TV	24	14	0.001692**
SS vs. NS	56	21	0.085169
SS vs. TV	56	14	0.451634
NS vs. TV	21	14	0.020528*
Fledglings Success (FS)			
Region vs. region	N recorded cases	N recorded cases	P
SG/ER vs. DH/WS	11	22	0.032833*
SG/ER vs. SS	11	29	0.06554
SG/ER vs. NS	11	17	0.105699
SG/ER vs. TV	11	9	0.420965
DH/WS vs. SS	22	29	0.746605
DH/WS vs. NS	22	17	0.611724
DH/WS vs. TV	22	9	0.004929**
SS vs. NS	29	17	0.846432
SS vs. TV	29	9	0.010944*
NS vs. TV	17	9	0.020143*

success. No significant difference was recorded in the success rate. Statistically very highly significant differences in productivity were recorded between the pairs in the region of the Dervent Heights/Western Strandja Mountains and those inhabiting the Tundja river valley ($p<0.001$) (Table 2). This indicator showed statistically highly significant differences ($p<0.01$) between mountain wooded areas and the area of Dervent Heights/Western Strandja. These differences were also valid for Dervent Heights/Western Strandzha and Southern Sakar, as well as Northern Sakar and the Tundja river val-

ley. Significant differences ($p<0.05$) were recorded between pairs in the Sredna Gora/Eastern Rhodope Mountains and Northern Sakar, and between those breeding in Southern Sakar and Northern Sakar.

Regarding the breeding success (Table 2), statistically highly significant differences ($p<0.01$) were recorded between Imperial Eagles breeding in Dervent Heights/Western Strandzha and Southern Sakar, as well as between those in Dervent Heights/Western Strandzha and the Tundzha river valley. The difference in this indicator between the mountain wooded territories and Dervent Heights/Western Strandzha, and between Northern Sakar and the Tundja river valley was significant.

Statistically highly significant differences in the fledglings success ($p<0.01$) were recorded between Dervent Heights/Western Strandja and the Tundja river valley, while those between Sredna Gora/Eastern Rhodope and Dervent Heights/Western Strandja and between the Tundja river valley and the two regions in the Sakar Mountains was significant ($p<0.05$) (Table 2).

The breeding parameters indicate highest values of the pairs breeding in Dervent Heights/Western Strandja, where during the period 2000-2009 with n=24 occupied territories the mean value of the breeding success and productivity was 1.58±0.38, the mean fledgling success 1.7±0.40 and the mean success rate 94.17% ±12.45. These are followed by the pairs breeding in Northern Sakar (n=21 cases of occupied territories), as the mean productivity and breeding success was 1.35±0.77, the mean fledgling success 1.56±0.64 and the mean success rate 83.34% ±20.4. The breeding success of the pairs (n=22) in the mountain-wooded areas of the Sredna Gora and Eastern Rhodope Mountains was not so good, as the mean value for the study period was 0.97±0.97. They had low fledgling success 1.17±0.94 and low productivity 0.76±0.67. Their mean value of success rate was 61.11% ±39.75. The lowest breeding success (0.65±0.44), fledgling success (0.88±0.64) and productivity (0.58±0.43) were recorded for pairs (n=18 cases) nesting in the Tundja river valley. Low values of mean breeding success (0.81±0.43) and productivity (0.73±0.43) were observed with the breeding group in the Southern Sakar Mountains, where 63 cases of occupied territories were recorded. The birds nesting in this region had mean fledgling success 1.59±0.38, but their success rate was the lowest (48.69% ±22.76).

For the ten years' study period, breeding immature eagles were not recorded in only 16.7% of the occupied territories. The presence of immature male birds (57%) in pairs was a bit higher than that of immature females (43%). The presence of immature birds in pairs was recorded after 2001 (Fig. 5). The maximum number of pairs consisting of an adult and an immature bird was recorded between 2003 and 2005, as in 2004 the number of pairs involving two adult individuals was almost equal to the number of mixed pairs. Eleven immature pairs occupied different territories between 2002 and 2009. Eight of these pairs were recorded in newly occupied and three in reoccupied territories. Since 2005, the number of adult pairs has been increasing.

Discussion

Breeding distribution and habitat performance

The existing data on the breeding of the species in the past, when it was widespread, is related to various habitat types (Hristovich 1890, Reiser 1984, Leverkuhn 1907). This was followed by a period of dramatic decline between the 1950s and 1980s, when birds of prey were declared a pest and a campaign for their extermination was launched (Petrov *et al*. 1996). This period is also related to a change in traditional farming, which resulted in serious fragmentation and loss of habitats, particularly evident in the plains. In the 1960s, as a result of human pressure, the species disappeared in most of its lowland localities, where it was easily accessible, and during the next decade its nesting distribution was present mainly in mountains, where it had survived probably due to the sparsely populated and not so accessible regions (Michev, Petrov 1979, 1985, Simeonov *et al*. 1990). Between 1970 and 1980, the Imperial Eagle was recorded in 21 localities, 76% of which were in the mountains, including all certain ones (Michev, Petrov 1979, Stoychev *et al*. 2007, Demerdzhiev, manuscript). During the next twenty years, 15 certain breeding localities were known, 53% of which located in the low hilly areas of the Sakar and the Western Strandja Mountains (Darakchiev, 1988, (Petrov *et al*. 1996, Stoychev 1997, Stoychev *et al*. 2004).

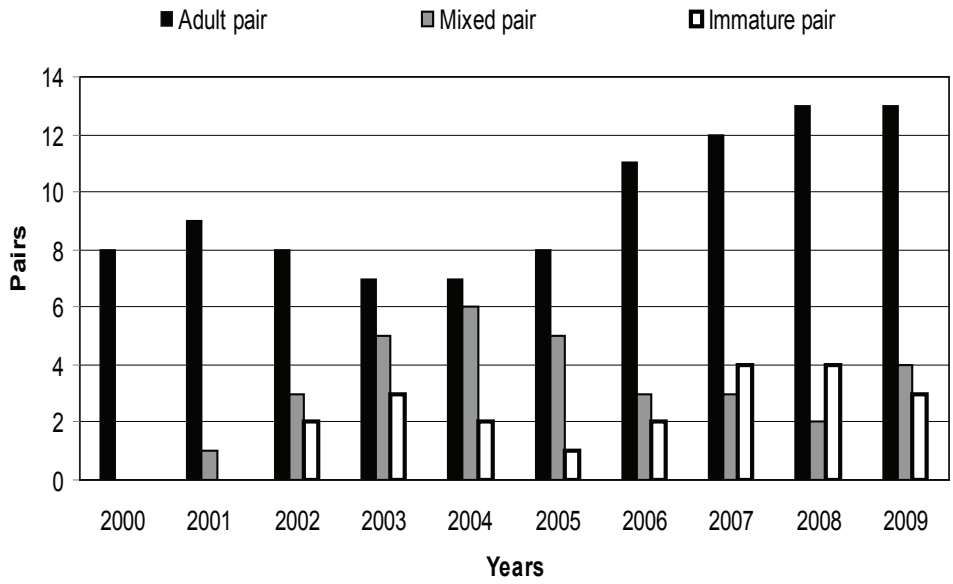

Fig. 5. Age structure of the Eastern Imperial Eagle breeding population for the period 2000-2009

The recovery of the population started in the Sakar and the Western Strandja Mountains, where the species had survived in the sparsely populated border areas. The expansion of the population in SE Bulgaria involves northward and westward colonization of new regions, holding many territories suitable for breeding.

According to Arabadzhiev (1962) the Eastern Imperial Eagle was found in the Sakar and the Strandja Mountains till about 1940, and then it disappeared. This, however, is at variance with the information from the local people, who know the species quite well. According to them, there have been no periods, when there were no Imperial Eagles (Petrov, Stoychev 2002). The studies carried out in SE Bulgaria by different ornithologists during the 1970s and 1980s presumed the existence of 3-4 pairs in the Sakar Mointains and 3-5 pairs in the Dervent Heights and the Western Strandja Mountains (Nankinov 1981, Lamburov 1985, Darakchiev 1988).

By 2000, six of all 8 occupied territories were situated in the Sakar and the Western Strandja Mountains. In the period 2001-2009, 13 newly occupied and 3 reoccupied territories were recorded. Annually, zero to three new territories were occupied, an average of 1.78±0.97 during the study period, all of them situated in lowland and hilly areas at an altitude of 50 m to 280 m in SE Bulgaria. The stabilization of the population in SE Bulgaria in the 1990s and the subsequent increase during the last decade of the 20th century was probably related to the existence of a stable Imperial Eagle population in European Turkey (Demerdzhiev *et al*. 2011). The studies carried out in 2008 and 2009 in Turkish Thrace ascertained an obviously healthy and relatively abundant Eastern Imperial Eagle population, which gives us reason to presume that the pairs breeding in SE Bulgaria represent the periphery of this Thracian population of Imperial Eagle expanding north-westwards.

At the same time the degradation of the territories in the mountain-wooded habitat type that started some twenty years ago continues after 2000. In the Eastern Rhodope Mountains, where only one breeding pair was recorded during the period 2000-2009 (Demerdzhiev 2004), since 2004 this territory has been occupied by the male eagle only. A decrease in the number of Imperial Eagles inhabiting this mountain was recorded as early as the 1990s (Hristov, Stoynov 2002). One of the two breeding territories in the Sredna Gora Mountains, which has been known since 1978 (Petrov 1981), was not occupied by birds in 2009. The Imperial Eagles in this territory have not bred since 2004. A loss of a 'mountain type' territory was also recorded in 1998 in the Eastern Balkan Mountains (Angelov 2009). In 2009 only one pair nested in mountain habitat type.

The species is often found in open plain areas when the population is abundant and not persecuted (Katzner *et al*. 2003). The expanding Panonian

(Hungary, Slovakia) population of the Eastern Imperial Eagle is also characterized by re-colonization of lowland territories (Danko, Chavko 1996, Bagyura *et al*. 2002, Horvath *et al*. 2011, Danko *et al*. 2011). The Spanish Imperial Eagle (*Aquila adalberti* Brehm, 1861), which, in an increasing population, occupies lowland territories, shows similar habitat preferences (Gonzalez *et al*. 2008). As the living conditions change, each habitat type can be crucial for the preservation of the population. According to Gonzalez *et al*. (2008), all habitat types used by the Spanish Imperial Eagle, including also those harboring few pairs, should be considered important for the species conservation.

Breeding parameters

Since the Imperial Eagle is a species with 'K' demographic strategy, characterized by low reproductive potential, balanced with significant life expectancy of breeding individuals, the survival of adults is the most important factor affecting the population growth (Newton 1979, Katzner *et al*. 2006, Soutullo *et al*. 2008). With stable populations the annual mortality of adults is equal to renewability (Ricklefs 1973, Newton 1979).

The mean survival rate of breeders recorded for the period 2000-2009 was similar to that of the increasing population of the Spanish Imperial Eagle (Ortega *et al*. 2009).

The annual mortality of breeders was lower than that of the declining local population of the Spanish Imperial Eagle in Doñana (Ferrer 2001). High adult mortality was recorded in the Eastern Imperial Eagle population of the Naurzum Reserve (Kazakhstan) for the period 1999-2002, probably because this was a migrating population (Rudnick *et al.* 2005). The mean values of the breeding parameters for the period 2000-2009 indicated the good health of the population, which is a precondition for its growth. The population of Imperial Eagles in Hungary had better breeding success and fledgling success for the period 2001-2009, respectively the mean values of 1.15 and 1.72, which was probably due to the higher percentage of three-chick broods (Horvath *et al*. 2011). The mean success rate for the period 2001-2009 in the Hungarian population was 67%, as for the Bulgarian population it was similar 64%. For the same period, however, 48% of the pairs in Hungary had two chicks each, and 14% of the pairs had three chicks per pair, while in Bulgaria the pairs with two-chick broods were 40%, and those with three chicks only 6.9% (Demerdzhiev manuscript). Higher breeding success was recorded in the population of the species in NW Kazakhstan – from 1.3 to 2 for the period 1990-2002 (Bragin, Katzner 2004) and for the Slovakian population for the period 2004-2007 (mean value 1.35) (Danko *et al*. 2011).

The lowest value of breeding parameters of pairs nesting in the Tundja river valley was probably due to the inexperience of the breeding birds occupying new territories. In the period 2002-2009, 50% of the pairs that had occupied breeding territories, consisted of partners in immature plumage. The region is characterized by plains, considerable open areas and arable lands, and the nests of the Imperial Eagle pairs are built on single trees or in isolated groups of trees, visible kilometers away, thus often subject to human disturbance. The low values of the breeding success and the productivity recorded for the pairs breeding in the Southern Sakar Mountains were also due, to a certain extent, to human disturbance. Some of the pairs breeding in the area are situated in the immediate proximity of settlements or roads; being often disturbed, they fail to raise chicks. However, some of the pairs nesting in this area occupied territories of low quality with considerable overgrowth and not so good food resources (Demerdzhiev, manuscript). Some of the birds breeding in this area have also been infertile for many years. The pairs breeding in the Northern Sakar and the Western Strandja Mountains, occupying territories providing better conditions and being less exposed to disturbance, had highest values of the breeding parameters. The disappearing pairs in the mountain-wooded habitat type, usually occupying territories of lower quality, also had lower values of the breeding parameters.

The age of first breeding is influenced by habitat heterogeneity and population density (Kruger 2005). In the raptor breeding populations, variable percentage is generally made up of individuals in non-adult plumage (Newton 1979). Breeding of non-adults within the population is determined by two main factors: 1. Increased adult mortality enables younger birds to breed replacing dead adults (Balbontin *et al*. 2003, Ferrer 2001, Ferrer *et al*. 2003); 2. Increased resource availability encourages non-adult breeders (Wyllie, Newton 1991, Brommer *et al*. 1998).

High adult mortality and availability of foraging and nesting sites can account for the presence of non-adult birds in pairs. In the first case, a significant part of the pairs were "mixed", consisting of an adult and an immature bird replacing a dead mate (Ferrer 2001, Ferrer *et al*. 2003). On the other hand, increased resource availability and vacant territories could encourage non-adults to breed (Wyllie, Newton 1991, Broomer *et al*. 1998). In these cases, pairs consisting of two immature birds colonize new territories. The peak of 'mixed pairs' in 2004 was definitely related to the higher mortality of breeders recorded for that year (9.7%). The appearance of immature pairs after 2002 was related to the colonization of new territories, indicating population growth. With the increase of the Spanish Imperial Eagle population, non-adult pairs occupy new territories (Gonzalez *et al*. 2006, Ortega *et al*. 2009).

Threats and conservation

The loss of breeding and feeding habitats is one of the main threats. Illegal felling of high trees deprives the Imperial Eagle of suitable nesting substrate. Most of the nests are built on Poplar trees (*Populus* sp. L.), often near roads, where the trees are easily accessible. With the increase of the population, the colonization of new regions can be hindered if high single trees in suitable breeding territories are cut. Planned clearing of big forest areas also has a negative effect on the potential nesting substrate of the species. Habitat fragmentation is perhaps the most serious factor, which could negatively affect the population in the future. Tilling vast areas abandoned for many years or traditionally used as pastures in the Sakar and the Sredna Gora Mountains and turning them into vineyards, orchards, or arable lands result in decreased numbers of prey species. Disturbance during the breeding season is another important threat. In the Tundja river valley, the Sakar and the Western Strandja Mountains, the nests are situated in open plains and sometimes close to agricultural fields and roads. Eagles are used to the presence of local shepherds and let them come close, often even under the nest tree, while incubating (own data). Farming activities involving more people and/or agricultural machinery result in high disturbance and brood loss.

One certain case of phosphoroorganic pesticide poisoning of Imperial Eagles from a breeding territory in the Western Strandja Mountains was recorded during the study period. One of them was an adult found dead under the nest, and the other poisoned bird was a fledgling found in the nest. One year later the breeding territory was occupied by a new immature pair. One case of direct persecution was reported also in the Strandja Mountains when a local shepherd killed an eagle near the nest and then cut the bird's legs (one of the legs was provided to the National Museum of Natural History). The bird was probably poisoned, because it could not take off from the ground. An immature Imperial Eagle shot with 12 pellets was recorded during the study period. There was one recorded case of nest robbing in the Tundja river valley, when local youths took the eggs at Easter time.

Electrocution or collisions represent potential threats. One of the juvenile Imperial Eagles tagged with satellite transmitters was found electrocuted at a distance of 1.5 km from its nest. The power line network in Bulgaria includes many dangerous structures posing risks to birds (Stoychev, Karafeizov 2004). The study on the risky 20 kV power lines carried out in 2004 within four Important Bird Areas (IBAs) of significance for the breeding of the species, or in temporary settlement areas, revealed high mortality rates of raptors caused by electrocution (Demerdzhiev *et al*. 2009).

Construction of wind farms and solar parks is another potential threat to Imperial Eagles. The green energy becoming increasingly popular in recent years, involving the construction of large-scale wind farms or solar facilities result in devastation of eagles' habitats and key prey species; these innovations could also be a direct cause of bird mortality. There are investment plans for the construction of wind farms or solar parks within the territories of ten Imperial Eagle pairs breeding in Bulgaria.

Natural disasters represent another important reason for bird mortality during the fledging period. Nine cases of chicks falling off the nests in storms were recorded during the period 2000-2009; these incidents caused the death of four eaglets and permanent injury of one.

Conservation activities implemented by both organizations – BSPB and Green Balkans, included: guarding of endangered nest sites; awareness raising campaigns; replacement of nests built at endangered

sites; construction of artificial nests; rehabilitation of injured nestlings fallen from the nests; restriction of forestry operation and agriculture field work; supplementary feeding; ringing of nestlings; satellite and radio tracking; educational activities; purchase of land around Imperial Eagle nests; planting of Poplar trees in good nesting habitats; and prevention of damage caused by European Sousliks (*Spermophilus citellus* Linnaeus, 1766).

All these systematic conservation activities have undoubtedly contributed to the population stabilization and the subsequent increase. Habitat conservation is of key significance for the stability and the continuous increase of the population. Currently, none of the active Imperial Eagle nests is situated within a protected area, as only an insignificant part of the hunting territories of two Imperial eagle pairs is protected. More territories inhabited by Imperial Eagles should be protected to secure the stability of the population.

Conclusions

The Eastern Imperial Eagle population in the country is increasing by an average of 1.78 pairs per year, the newly colonized territories being lowlands in SE Bulgaria, while the number of mountain-wooded pairs is decreasing.

The eagles breeding in the Western Strandzha Mountains had higher breeding success, hence higher productivity, than the pairs in the other regions.

The presence of immature pairs in the population is related to newly occupied or reoccupied territories.

Imperial Eagle habitats in Bulgaria are insufficiently protected.

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Увеличаване на популацията на Източния Царски орел (*Aquila heliaca*) в България

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(Резюме)

След 2000 г., системните консервационни дейности довеждат до подобряване на популацията на Източния Царски орел (*Aquila heliaca* Savigny 1809) в България. Популацията се изчислява на 25-30 двойки. През периода 2001-2009 г. са регистрирани 13 ново заети и 3 повторно заети територии. През 2009 г. броят на известните заети територии нараства до 20. Ежегодно са отчитани заетите територии, гнездящите двойки, гнездовите параметри на популацията, преживяемостта при възрастните индивиди и възрастовата структура на гнездовата популация. Средните стойности на гнездовите параметри на популацията за периода 2000-2009 г. са както следва: продуктивност 0.90±0.23; гнездови успех 1.01±0.26; размножителен успех 1.56±0.25; и успеваемост 64.45% ±11.52. За опазването на вида се изпълняват дейности като охрана на гнезда, рехабилитация на ранени птици и последващо връщане в природата, "преместване на двойки", изкуствено подхранване, изграждане на изкуствени гнезда, повишаване на осведомеността сред местната общност и власти, управление на гнездови местообитания, опръстеняване на малки в гнезда, сателитно и радио проследяване и закупуване на земи около гнездата. Основните заплахи за вида са загуба на местообитания, безпокойство, отстрел, отравяне и природни бедствия.