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Movements of Mute Swan *Cygnus olor* (Gmelin, 1789) (Anseriformes) Based on Hungarian Ringing Data

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Abstract: Movements of the mute swan *Cygnus olor* were studied based on the database of the Hungarian Bird Ringing Centre (BirdLife Hungary). A total of 20,335 recoveries of 6,806 individuals were evaluated, which yielded new information about migration routes, moulting and wintering grounds of this species. Apart from local recoveries, a total of 1,265 birds (21.3%) have been reported from abroad out of the total 5,940 swans originally ringed in Hungary. The recovery sites were mainly situated in the Balkan region as well as north-west and north-east from Germany (e.g. Germany, Poland, the Baltic region). The Hungarian breeding population was mostly sedentary, but short-distance winter migration also occurred to the Balkan region. The wintering mute swan population was in the range of 1,000-1,200 individuals consisting of native birds, but also including immigrants with the highest numbers coming from south Poland. Recoveries from longer distances (e.g. Denmark, Russia) were typical in severe winters. The number of moulting mute swans in Hungary was estimated to be 800 individuals, which were mostly local birds; however, considerable numbers of individuals were also arriving from the Croatian and south Polish populations.

Keywords: colour marking, distance of movements, moulting ground, ring recoveries, winter migration.

Introduction

The mute swan *Cygnus olor* (Gmelin, 1789) is a widely distributed Palaearctic species. According to the historical ornithological reviews, it is a native species in Hungary and has bred in natural marshlands until its extinction in the second half of the 19th century (Horváth & Kárpáti 1985). From the 1970s, a slow natural reintroduction has started from the feral populations of south Germany and Austria (Horváth & Kárpáti 1985, Szinai 1998), which led to the establishment of a stable breeding population of approximately 400 pairs (Albert & Szinai 2009). While mostly considered as a sedentary species, it is entirely or partially migratory in some areas of Europe (Cramp & Simmons 1977). Besides the large number of literature on the distribution, ecology and behaviour (*e.g.* Bart et al. 1991, Wieloch 1991, Włodarczyk & Wojciechowski 2001, Włodarczyk et al. 2013), recently there is an increasing number of studies and new information on the migration pattern and movements of the European mute swan populations (e.g. Fransson & Pettersson 2001, Bønløkke et al. 2006, Heneberg 2006, Blüml et al. 2012). Independently of the direction, the migration strategy of the mute swan is mainly characterised by the search for the nearest suitable wetland habitat, both in the moulting and wintering period (Albert & Szinai 2009).

The aim of the present study was to attempt to determine the directions and distances of movements of birds marked in Hungary. Further goal was to evaluate the whole mute swan ringing database of the Hungarian Bird Ringing Centre (BirdLife Hungary), also including recovery data of birds ringed abroad. Thus, we could verify whether our conclusions drawn from the

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data match the knowledge on migration pattern of the relevant European populations (Hilprecht 1970, Bauer & Glutz von Blotzheim 1990, Wieloch 1991, Scott & Rose 1996, Delany et al. 2006).

Materials and Methods

Catching and marking

For this study the database of Hungarian Bird Ringing Centre (BirdLife Hungary) has been used (capture-resighting and recovery data). Apart from two earlier re-sighting data from the middle 1950s, the mute swan dataset covers the period from March 1981 to August 2013.

In Hungary, mute swan ringing has started quite late, from the beginning of the 1980s. The authors of this paper marked a total of 2,114 birds (35.6%) out of the total 5,940 swans ringed in Hungary. The individuals were ringed with Budapest metal ring and, partly, with colour rings. Colour marks are linked to the international coding system. They have four-digit alphanumeric codes (black characters on yellow ground). Mostly colour leg (tibio-tarsus) rings were used. Occasionally neck-collars have also been used, especially for the breeding pairs and the large enough cygnets, as well as for the foreign ringed birds. We used special waterproof glue to secure all of the colour bands. Between 2003 and 2011 birds were ringed with Swedish-made large-number-engraved aluminium rings to avoid the high percentage of ring loss which was experienced in the case of the old Hungarian-made metal rings with no locking mechanism to secure. Andersen-Harild (1971) estimated a 7–8% ring loss on plane metal rings (rings without clip) in case of the mute swan, while we observed about 20% of annual ring loss. Nowadays, only stainless steel rings are used. During ringing the regular ringing protocol (age, sex, place, date) was applied. Normal or immutable forms were also indicated, more regularly in the last two decades.

Re-sightings

Until August 2013, over 20,335 sightings of mute swans have been reported. Metal rings are difficult to read in the field, but usually last the life of the bird. Colour rings and neck collars are easily read from a distance. Together, the two types of marking help to identify an individual mute swan with field records helping to provide a more extensive life history of individual birds.

Analyses

To analyse the migration pattern, all observations of the given period were used. Basically six types of data were available for the analyses according to the place of marking and to the ring type: 1. marked abroad with metal and colour rings; 2. first marked abroad with a metal ring, later also in Hungary with a colour ring; 3. marked abroad with a metal ring only; 4. marked in Hungary with metal and colour rings; 5. first marked in Hungary with a metal ring, later also abroad with a colour ring; 6. marked in Hungary with a metal ring only.

To compare the proportion of re-sightings of metal and colour ringed mute swans, a chi-square test was used. In this analysis only Nr 4 and 6 from the previously mentioned categories were entered. Average values of recovery frequencies of metal and colour ringed birds were compared by using a t-test. Mean distances of the movements of different aged birds were compared by performing one-way ANOVA and Tukey's pair-wise comparisons. Three age classes were determined: 1y, 1+ and 2y< (adult). All statistical analyses were carried out using the statistical software Past ver. 2.17b (Hammer et al. 2001).

Results

Mark – re-sightings

The database of the Hungarian Bird Ringing Centre lists a total of 6,806 mute swan individuals, of which 87.3% are Hungarian ringed birds (Fig. 1a); 78.3% of the total number of recoveries (20,335) was related to birds marked in Hungary (Fig. 1b).

In Hungary, the first mute swan was ringed in 1981 (Lake Fertő). The increase of the population was reflected notably also in the number of marked birds from 1983 (Fig. 2). The proportion of the individuals banded with colour rings was 32%.

Most of the individuals were captured and also observed in winter (January), which could be explained by the high degree of aggregation of swans on the non-freezing rivers and lakes. The minimum of capture/marking and resightings occurred in the breeding period (especially in May) while slightly increased number of birds had been marked and observed during the moulting period in July-August (Fig. 3).

The sex ratio of the ringed swans was almost equal (males 55% : females 45%). Regarding the age structure, almost half of the marked birds were age 2y and 2+ (Fig. 4).

The number of recoveries increased after the introduction of colour marking, most notably towards the end of the 1990's (Fig. 5). The re-sighting rate of the colour ringed birds (82.8%) was significantly higher in comparison with the re-sighting rate of the individuals marked with a metal ring only (chi-square test χ^2=43.21, P=0.0000).

Fig. 1. a. Mute swan marking in Hungary and abroad; **b.** Mute swan re-identification from Hungary and abroad.

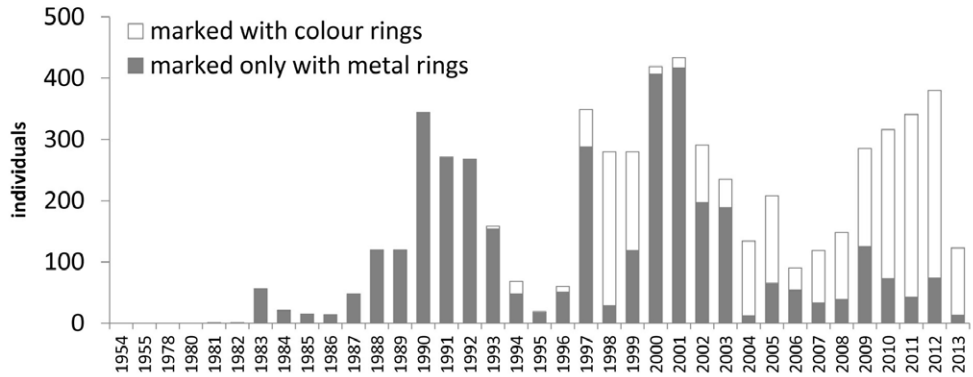

Fig. 2. Annual number of mute swans marked in Hungary.

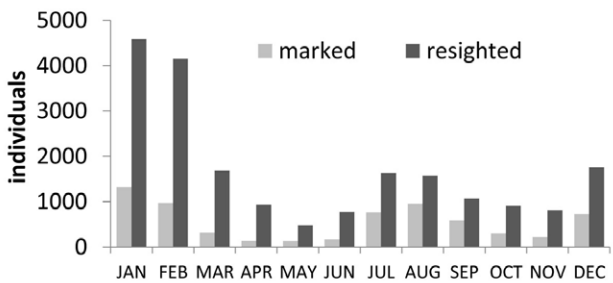

Fig. 3. Monthly mute swan markings and re-sightings.

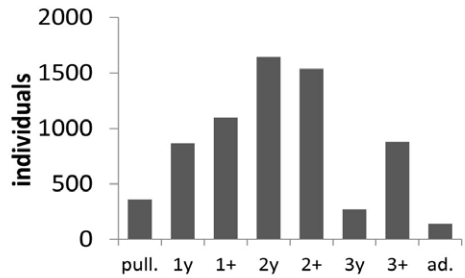

Fig. 4. The age structure of the marked mute swans.

The recovery frequency (observation/individual) of the identified Hungarian colour ringed swans was 5.9 ± 0.2 (mean ± s.e.), while its value was significantly lower 0.7 ± 0.0 for the metal ringed birds (t = 31.59, P = 0.0000). The most frequently observed mute swan was ringed in 2001 as age 3y on the Danube River (Nagymaros, Hungary) and since then it was resighted 103 times, mostly in the vicinity of the ringing place but also in Poland.

Movements

The mean distance of movements from the place of capture was 90.6 ± 1.1 (mean ± s.e.) km. Regarding the age classes, there was a significant difference in the mean distance of movements between the young birds (1y), the birds of 1+ years of age and the 2< years of age adults (One-way ANOVA $F_{2, 765}$ = 39.09, P = 0.000, Tukey HSD $P \leq 0.006$; Table 1).

The high number of local resightings of individuals ringed in Hungary implies that a part of the Hungarian population is sedentary. Apart from local recoveries, a sample of 18 foreign recoveries of mute swans connected with Hungary was available (Table 2). Out of the total 5,940 swans originally ringed in Hungary, a total of 1,265 birds (21.3%) have been reported from abroad. The recovery sites of these swans were mainly situated in the Balkan region (Croatia, Slovenia, Serbia), in Italy and north-north-east from Hungary (Slovakia, the Czech Republic, Poland, Ukraine, Belarus and the Baltic region; Fig. 6). It is noteworthy to mention the recoveries from the north-west (Germany and Denmark), while there are some sporadic data also from south-eastern countries (Romania, Greece). The mute swan recovery related to Spain merits a special mention. The bird was ringed in August 1989 at Lake Fertő (Hungary) and found injured in December of the same year on the

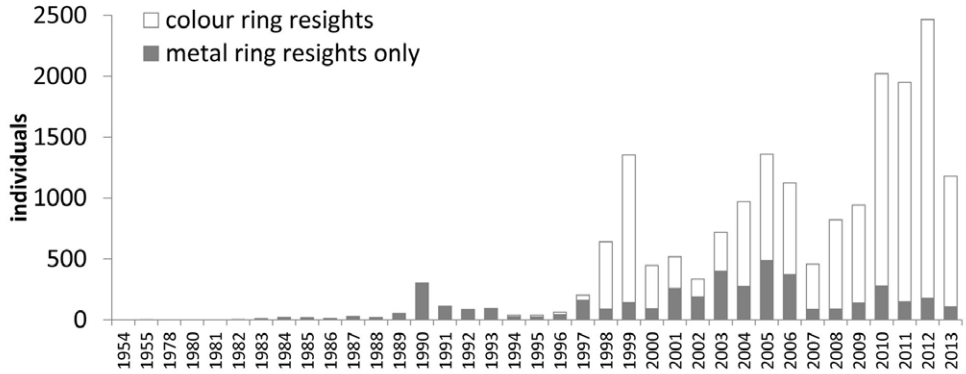

Fig. 5. Annual number of re-sightings of mute swans marked in Hungary.

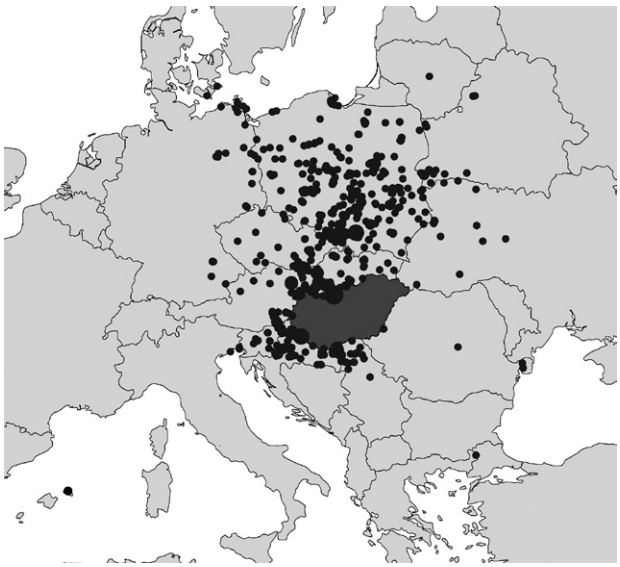

Fig. 6. Foreign recovery sites of mute swans marked in Hungary (l marking size is proportional to the quantity of re-sighted birds).

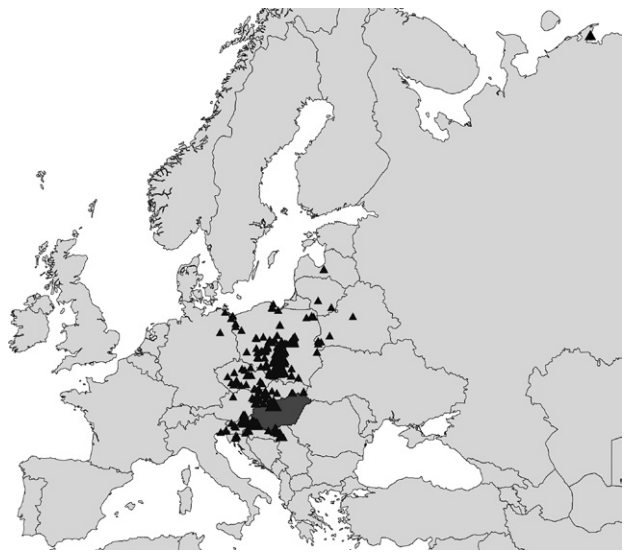

Fig. 7. Foreign ringing and recovery sites of mute swans observed in Hungary (pmarking size is proportional to the quantity of re-sighted birds).

Table 1. Distance of movements of mute swans ringed in Hungary. Differences in the distance of movements between the age-classes of mute swans (One-way ANOVA, Tukey HSD)

	1y	**1+**	**Adult (2y<)**
N	32	214	522
Min.	0	0	0
Max.	165	849	923
Mean	37.9	215.9	320.9
SD	37.3	195.8	228.9
	1y	**1+**	**Adult (2y<)**
1y		0.000	0.000
1+	7.35		0.006
F	11.70	4.34	

Menorca Island (Spain), at a distance of 1,325 km from the ringing place.

The ringing and recovery sites of birds observed in Hungary (Fig. 7) showed a similar pattern. From the south – south-west direction, shorter movements had birds from Serbia, Croatia and Slovenia. From the north, mute swans mostly arrive from the area between 13°E and 20°E (*e.g.* Germany, Poland, Belarus, Lithuania), with the exception of a particular case. In August 2006, a 2y bird (sexed as a female) was caught and ringed in the Pechora Delta (Russia, 68°30'N 53°50'E), in the Gulf of Korovinskaia, between the islands of Khabuika and Lovetskiiy by the team of Wildfowl & Wetlands Trust (J. Newth, pers. com.). Five years later, in January 2011, the bird was resighted several times on the Danube River, Budapest (Hungary). The distance between the ringing and wintering site is 3,073 km, which appears to be the longest distance of movement published up to the present date in the Eurasian region.

The ringing and re-sighting data allowed us to present here detailed movements of two mute swan individuals observed in more than one country after ringing (Fig. 8). In March 2005, an undoubt-

Table 2. Ringing and recovery sample statistics of mute swans connected with Hungary.

	Number of ringed individuals		Total recoveries				Recoveries of Hungarian ringed birds			
			Number of individuals		Number of re-sightings		Number of individuals		Number of re-sightings	
Austria	16	0.2%	151	3.1%	436	2.1%	137	3.7%	394	2.5%
Belarus	9	0.1%	30	0.6%	49	0.2%	29	0.8%	48	0.3%
Czech Republic	20	0.3%	38	0.8%	83	0.4%	35	0.9%	68	0.4%
Germany			26	0.5%	65	0.3%	23	0.6%	61	0.4%
Denmark			2	0.0%	4	0.0%	2	0.1%	4	0.0%
Spain			1	0.0%	1	0.0%	1	0.0%	1	0.0%
Greece			1	0.0%	1	0.0%	1	0.0%	1	0.0%
Hungary	5940	87.3%	3299	68.7%	15791	77.7%	2430	65.8%	12263	77.0%
Croatia	285	4.2%	280	5.8%	615	3.0%	249	6.7%	554	3.5%
Italy	6	0.1%	8	0.2%	27	0.1%	3	0.1%	17	0.1%
Lithuania	1	0.0%	2	0.0%	2	0.0%	1	0.0%	1	0.0%
Latvia	2	0.0%								
Poland	210	3.1%	309	6.4%	1398	6.9%	272	7.4%	1228	7.7%
Romania	71	1.0%	3	0.1%	5	0.0%	3	0.1%	5	0.0%
Republic of Serbia			99	2.1%	214	1.1%	84	2.3%	185	1.2%
Russian Federation	1	0.0%								
Slovakia	208	3.1%	494	10.3%	1551	7.6%	372	10.1%	1012	6.4%
Slovenia	37	0.5%	42	0.9%	71	0.3%	37	1.0%	61	0.4%
Ukraine			16	0.3%	22	0.1%	16	0.4%	22	0.1%
Total	6806		4801		20335		3695		15925	

edly Polish origin adult (3+) female sexed bird was caught and ringed in Esztergom, Hungary. The bird spent the summer in Poland, where it was observed three times during the period from 6 May to 4 September of the same year. For wintering, the bird migrated to northern Italy where it was first seen on 6 November 2005 (Staranzano, Isola della Cona), not only spending there the winter but also the whole following year 2006, as proved by the 14 resightings during that period. Subsequently, the bird returned to Poland (Zelezniki, Krosnice) in the spring of 2007. Another interesting case was a male mute swan ringed in December 1998 in Budapest, Hungary. After a re-sighting in January 1999 south from Budapest (Ráckeve), the bird was observed in Ukraine twice (13 April and 9 May) during the breeding period. Surprisingly, the bird changed wintering area and migrated to northern Germany (Neureetz, Märkisch-Oderland), where it was observed in January 2000. Two years later, in January 2002, the bird was found dead in Greece (Orestiada, River Evros), which indicated that this individual had changed its wintering area at least twice.

Discussion

Based on the geographical population division by Atkinson-Willes (1981), complemented by Wieloch (1991), the mute swans inhabiting Hungary belong to the west Ukrainian–Hungarian group, bordered by the Scandinavian-Baltic group from north and by the Central European group from north-west. This subpopulation has been growing and extending to the Balkan region (Monval & Pirot 1989, Wieloch 1991, Tucakov 2005). With the growing Hungarian population the mute swan ringing activity had also increased, which yielded new information about migration routes, moulting and wintering grounds of this species. The number of resightings increased significantly with the use of colour rings, because of the easier re-identification, which has been supported by several studies of other species demonstrating the effectiveness of this method (e.g. Rock 1999, Meissner & Bzoma 2011). The peak of recoveries resulted in the wintering period, when the birds are aggregating on the non-freezing water bodies, mainly on Lake Balaton and on the Danube and Drava Rivers (Szinai 1998). Mute swans are showing tolerance towards human presence and can also benefit from the anthropogenic food resources (Włodarczyk et al. 2013), particularly in cold winters, by staying on ice-free stretches of rivers in urban areas (e.g. the Danube River in Budapest), where they are often fed by people (Dolata 1998, Heneberg 2006, Albert & Szinai 2009). In Hungary, the wintering mute swan population was in the range of 1,000-1,200 individuals, mostly consisting of native birds but also includ-

ing immigrants from Slovakia, the Czech Republic, Germany, Poland, Latvia, Lithuania, Russia, Belarus and Ukraine (Wieloch 1991, Szinai 1998, Albert & Szinai 2009).

Over the last decades, it has also become a more frequently observed phenomenon in many countries that swans tend to shorten migration distances between the breeding and wintering sites or to become sedentary (Wieloch 1991, Švažas et al. 2001, Wieloch & Remisiewicz 2001, Tryjanowski et al. 2013, Włodarczyk et al. 2013). According to the recovery data, part of the Hungarian mute swan population can be considered sedentary. At the same time, short-distance winter migration also can be observed. The wintering grounds of the Hungarian mute swan population are mainly the hydropower system ponds near Cakovec (Croatia), but some individuals continue their migration close to the mouth of the Drava River (Kopacki rit, Croatia). The southernmost wintering sites of the Hungarian breeding birds are near to Novi Sad (Serbia). Long distance movements of swans breeding in Hungary are not known (Albert & Szinai 2009).

Mute swans may return to the same wintering areas, but may visit other localities, sometimes far from the one used in previous years (Dorowin 1986, Wieloch 1991). This was the case with the Hungarian ringed bird of Ukrainian origin, later observed wintering also in Germany and Greece. This phenomenon might be explained with the climatic conditions. Especially extremely cold winters may have an effect on wintering ground selection. Another explanation might be in relation with different groups of mute swan populations that often merge as a result of range expansion (Wieloch 1991). As a consequence, individuals of different populations may interact easily often, forming new pair bonds, which might have an influence on the migration route of at least one of the individuals of the mixed pair.

Apart from providing an optimal wintering ground for birds arriving from north, the Carpathian Basin also plays an important role during the moulting period. The number of moulting mute swans in Hungary has been estimated to be approximately 800 individuals. The most important moulting grounds are the large fishpond systems and the southern shore of Lake Balaton. In the later area, the number of moulting birds ranged from 500 to 600 individuals, while the breeding population was only between 30–50 pairs. Mute swans moulting in Hungary were mostly local birds, however, considerable number of individuals from the Croatian and South-Polish population may change their moulting grounds and appear here, as supported by the recovery data.

With reference to the results of mean distances of movements of the different age classes, juvenile swans are more likely to be resident as compared to the 1+ and adult (2y<) birds. This phenomenon was observed also in other European populations (Wieloch 1991, Blüml et al. 2012).

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