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THE MIGRATORY FATTENING OF THE BARN SWALLOW *HIRUNDO RUSTICA* IN HUNGARY

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Studies conducted within the framework of the EURING Swallow Project in the Mediterranean area pointed out that the fattening of Barn Swallows is dependent on the distance they need to cover to pass over ecological barriers, such as sea and desert via their migration route. Our study was conducted at inland sites and we analysed the data in comparison to results previously obtained in the western Mediterraneum. Barn Swallows were captured at two roosting sites in Hungary: Ócsa peat bog and Izsák, at Lake Kolon between 2000–2002 with tape-luring set up each day one and a half hours before sunset. During the study period 7000 adult and 36000 juvenile Barn Swallows were caught. Wing length, 3rd primary length, tail length, body mass and fat score were measured for all adults and for the first 100 juveniles birds each night. Based on the dynamics of fat accumulation the study period was separated to a post-breeding, a transitional and a pre-migratory phase. The observed pattern between years and sites were similar, and there were recaptures during the same autumn between the two roosting sites (60 km from each other) to north and to south direction as well. Our results can not exclude one of the two alternative hypotheses on Barn Swallow migration strategy that is: (1) Barn Swallows build up their fat reserves in Hungary and afterwards they maintain it while slowly reaching the ecological barriers, and (2) Barn Swallows capable of a non-stop migration from Hungary to the southern edge of the Sahara. Efforts to find important refuelling sites in the eastern Mediterranean are needed to support any of the hypotheses.

Keywords: Barn swallow, fat stores, Hungary, migration, Mediterranean

INTRODUCTION

The Barn Swallow is a widespread species in Eurasia and North America with an estimated global population of 190 000 000 pairs although it is recognized that the species underwent a moderate population decline at least in Europe in the last few decades (BirdLife/EBCC 2004). This species undertakes one of the longest migratory journeys among migrants (CRAMP 1988, ALERSTAM 1990). The Barn Swallow is a well studied species, and our knowledge is comprehensive and supported by large datasets collected especially in the framework of the EURING Swallow project (SPINA 1998, 2001).

European long-distance passerine migrants have to cross the Mediterranean Sea and the Sahara Desert during the migration to and back from Africa. Most species where information is available leave their breeding area with a relatively low fat deposit, and gain body mass along the migratory route until they become able to cross these ecological barriers (BIBBY & GREEN 1981, BAIRLEIN 1991, KAISER 1992). The Barn Swallow is an aerial feeder, thus it is not tied to particular stopover habitats as numerous long-distance migrants do. Because of this characteristic the species was considered to be able to refuel during migration and to cross the ecological barriers with a relatively low fat deposit (DAVIS 1965, MEAD 1983, ORMEROD 1989, 1991, CRAMP 1998). Recent studies has shown that the pre-migratory fattening of the Barn Swallow can reach up to 30–40% of its lean body mass, which is comparable to the fat accumulation of other long-distance migrants. These fat stores can be sufficient to cross ecological barriers up to 3000–4000 km (PILASTRO & MAGNANI 1997, PILASTRO & SPINA 1999).

Studies performed within the framework of the EURING Swallow Project in the Western Mediterranean area pointed out that the fattening of Barn Swallows depends on the distance necessary to pass over ecological barriers on their migration route (RUBOLINI *et al.* 2002). These studies were conducted mostly in the western and central part of the Mediterranean area at well known roosting sites.

Our study was conducted at inland sites and we analyzed the data in comparison to the Mediterranean data (RUBOLINI *et al.* 2002). Over the last three decades, large numbers of swallows (20000–35000/year) breeding or migrating through Hungary were ringed during autumn migration. From among these birds only a small fraction was recaptured during the same autumn migration period in the area between Hungary and the southern edge of the Sahara. These recaptures originate solely from Serbia, Slovenia, Croatia at inland sites and not from more southern parts of the eastern Mediterranean. Based on existing data from the central and western parts of the Mediterranean (Iberian and Appennine peninsula) further stopover sites are expected to exist in the eastern part of the Mediterranean, as well.

In this study we investigated different hypotheses with regards to the migration patterns of Barn Swallows in the central part of Europe based on data collected from two different but connected roosting sites in Hungary. We principally tested whether Barn Swallows accumulate sufficient fat to enable them to reach Sub-Saharan Africa from Hungary with non-stop flight or whether there is a need for refuelling sites along their travel route in the Mediterranean basin.

MATERIALS AND METHODS

The birds were captured at two roosting sites in Hungary: Ócsa (47°19'N 19°13'E) in 2002 and Izsák, Lake Kolon (46°47' N 19°21'E) between 2000–2002. Both areas hold large reedbeds, which is the primary roosting habitat for swallows in Hungary. Ócsa Öregturján is a post-glacial peat-bog area. Izsák, Lake Kolon is a highly eutrophic lake, which is covered by vegetation, predominantly reeds. Swallows were caught with tape-luring set up each day one and a half hour before sunset. During the study period 7000 adult and 36000 first-year Barn Swallows were caught.

Wing length, 3rd primary length, tail length, body mass and fat score were measured for all adults and for the first 100 first-year birds each night in accordance with the generally accepted standard data collection methods (SZENTENDREY *et al.* 1979, JENNI 1998). Date, time of capture, age and sex were recorded for each individual specimen, as well (SVENSSON 1992).

Fat scores provide a widely utilized index of lipid stores and serve well in comparative analyses since it is independent of size. Fat score was recorded on a 0–8 scale according to the method described by KAISER (1992). In further analyses the fat score was transformed to ln(1 + fat score) in order to improve normality (BROWN 1996).

Migration phases

Two different phases were identified similarly to the study of RUBOLINI *et al.* (2002). The post-breeding (PB) period lasts from the 1st of July until the 20th of August while the pre-migratory (PM) phase extends from the 1st of September until the end of October. The period between the two phases was excluded as a transition period. Our dataset included 4989 birds from the PB and 7081 birds from the PM phase.

Statistical analyses were carried out with the Statistica software (StatSoft Inc. 2001) using ANOVA and ANCOVA models and Tukey HSD multiple comparison procedures.

Testing differences between sites and years of capture

The differences between the two sites in 2002, and between years of capture at Izsák were tested with ANOVA, where wing length, body mass and fat score were the dependent variables and site or year, age and migration phase (PB, PM) were factors. To avoid the bias introduced by the fact that on average longer wing length was noted in one group we used ANCOVA models where body mass and fat were the dependent variables, age and migration phase were factors and wing length was a covariate. We tested the differences between years and sites from the models.

Estimated Departure Fuel Load

In order to compare the size of fat reserve of these birds, EDFL (Estimated Departure Fuel Load) was estimated according to the Mediterranean study of RUBOLINI *et al.* (2002) for the different sites and years. We estimated lean body mass (LBM) as the average mass of birds with fat = 0 (PILASTRO & SPINA 1999). A single mean value of 17.9 g was used taken from the study of RUBOLINI *et al.* (2002). To obtain a rough estimate of the fat reserves carried by individual birds ready for departure, we subtracted the LBM from the total body mass of the highest quartile of birds by weight (BIEBACH 1990, BAIRLEIN 1991). This exercise was done separately for each study sites and age class during the PM phase. We defined this value as the estimated departure fuel load (EDFL thereafter, expressed as % LBM). *t*-tests were used to test the differences between average body mass, fat score and EDFL values between the two study sites and results of RUBOLINI *et al.* (2002).

Recoveries

All foreign recoveries were obtained from the databank of the Hungarian Bird Ringing Centre. The recoveries were plotted on maps for autumn and spring migration in order to provide a summary map on the use of established stopover sites in the Mediterranean.

Flight ranges

Flight ranges were estimated with the Flight 1.1.7 Software (PENNYCUICK 1989, 1998, PENNYCUICK *et al.* 2000). The percentage of birds able to cross the Mediterranean and the Sahara desert were calculated for our database. 1800 km were used as minimum distance to travel to the southern edge of the Mediterranean and 3600 km to the southern edge of the Sahara. These distances are 600 km longer, than the longest route from the comparative western Mediterranean study. We used an average 17.9 g lean body mass (LBM) for the flight range models, when data was used to compare to the Mediterranean data (PILASTRO & SPINA 1999). The models were run with the assumption that the body mass of Barn Swallows rarely can decrease to under 15 g alive, so the model birds were allowed to migrate until they reached this body mass.

RESULTS

Differences between sites

The ANOVA results show that the average body mass and fat score was significantly higher at Izsák than at Ócsa in 2002 (body mass: $F_{1,11888} = 282.61$, $p < 0.001$, fat score: $F_{1,12056} = 493.08$, $p < 0.001$, Fig. 1). We found that the wing length is longer as well ($F_{1,11961} = 73.73$, $p < 0.001$). The test on body mass is significant for the site-migration phase interaction ($F_{1,12056} = 36.332$, $p < 0.001$) revealing that between sites there is only a small difference in body mass in the PB phase, which becomes larger for the PM phase. With the use of the residuals from the ANCOVA models the identical differences are noted (body mass: $F_{1,11599} = 493.89$, $p < 0.001$; fat score: $F_{1,11599} = 751.00$, $p < 0.001$), suggesting that if corrected for age, migration phase and wing length differences, the same pattern remains in average body mass and fat score (Fig. 2). The daily average body mass for both ages runs parallel for the two sites (Fig. 3).

Differences between years

The ANOVA results demonstrate significant differences between years at Izsák in body mass and fat score (body mass: $F_{3,18583} = 71.40$, $p < 0.001$; fat score: $F_{3,18583} = 14.71$, $p < 0.001$). A difference in wing length between years could be seen, as well (wing length: $F_{2,18102} = 18.97$, $p<0.001$). With the use of the

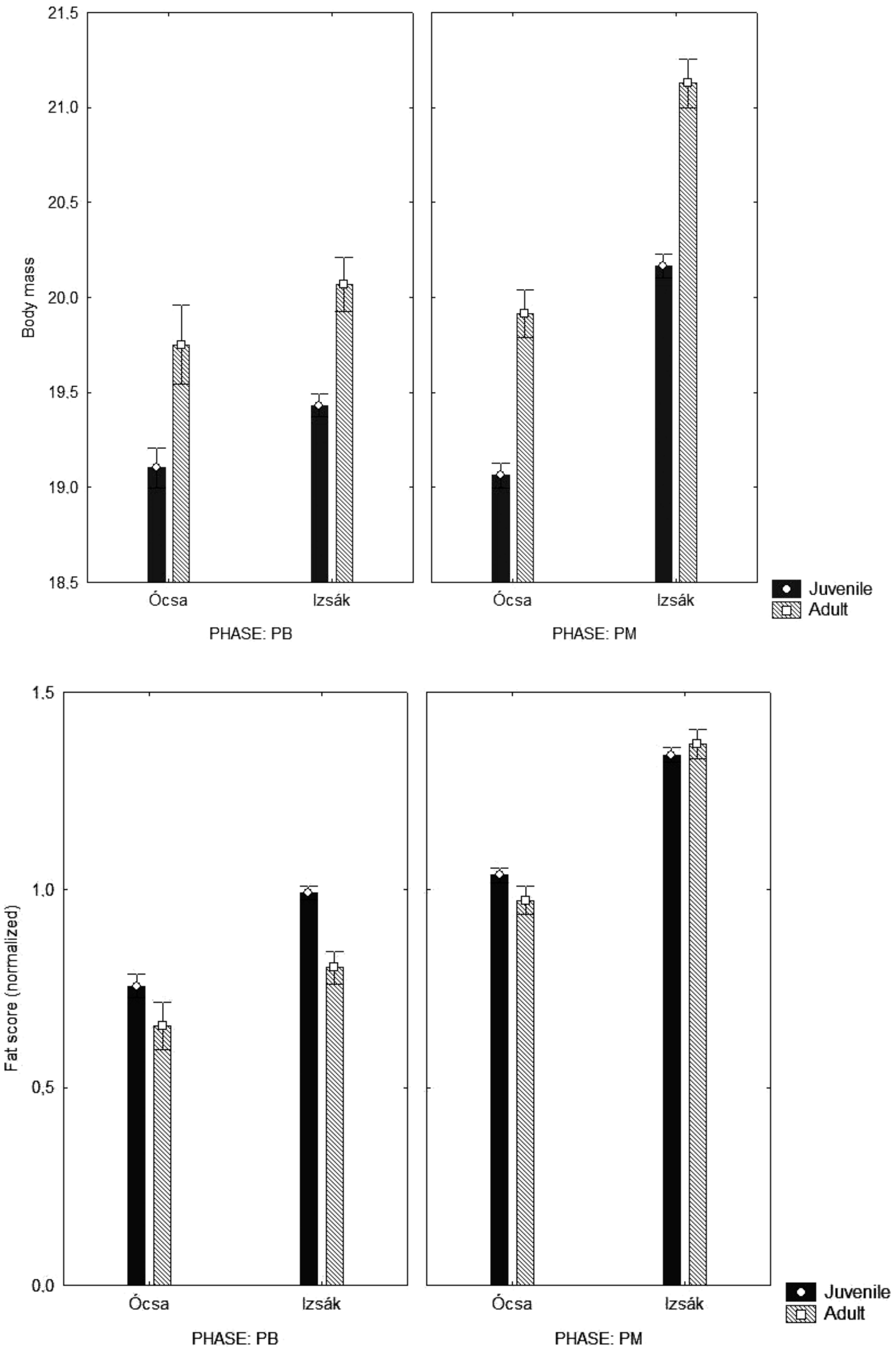

Fig. 1. Differences in body mass and fat score of Barn Swallows between Ócsa and Izsák in 2002

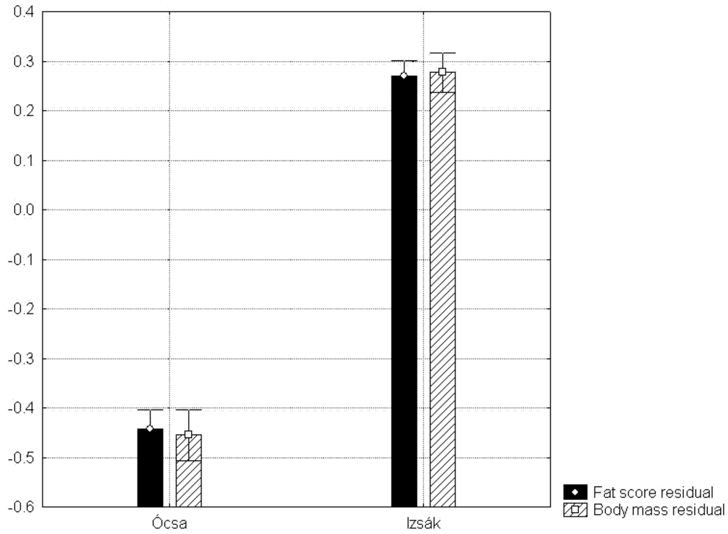

Fig. 2. Differences in residuals from ANCOVA models between Ócsa and Izsák in 2002

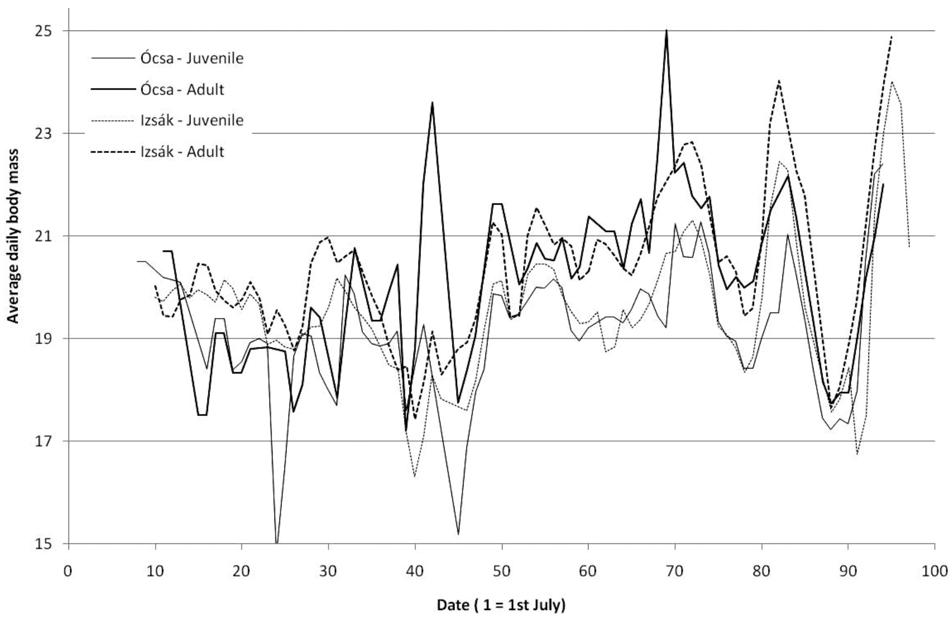

Fig. 3. Daily average body mass for juvenile and adult Barn Swallows at Ócsa and Izsák in 2002

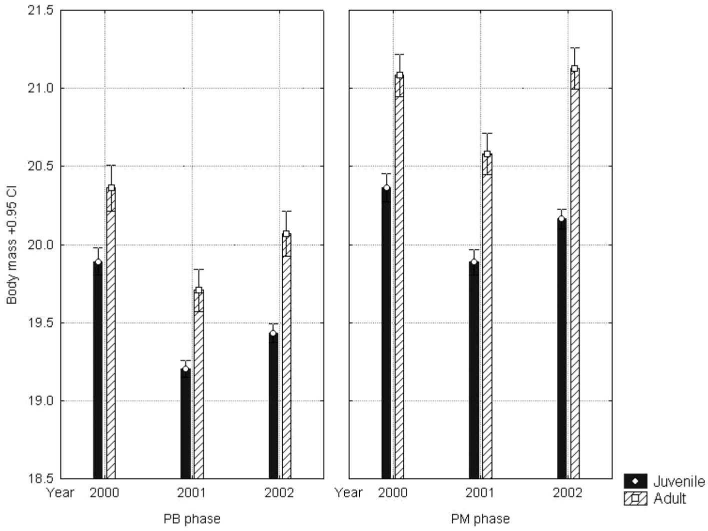

Fig. 4. Differences in body mass of Barn Swallows between years at Izsák 2000–2002

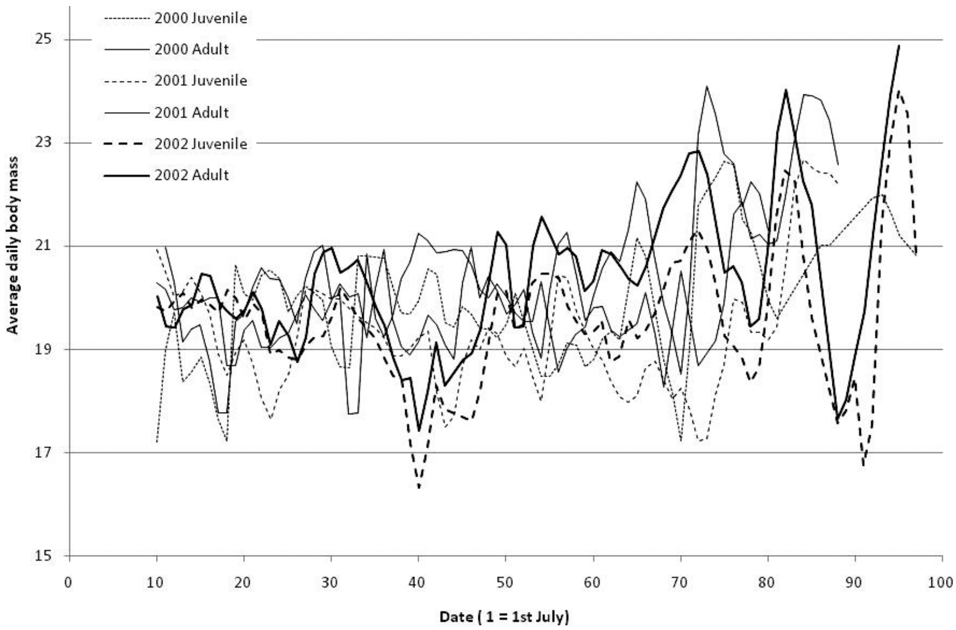

Fig. 5. Daily average body mass for juvenile and adult Barn Swallows at Izsák between 2000–2002

ANCOVA model residuals the same pattern remains again (body mass: $F_{2,18111}$ = 105.71, p < 0.001; fat score: $F_{2,18111}$ = 53.935, p < 0.001, Fig. 4). The daily average body mass shows a different pattern for each year, with minimum and maximum points on different dates per year (Fig. 5).

Age groups and periods

In each analysis we found that in the PB phase juveniles have larger fat stores than adults for each year of study and both sites of observation (2002: $F_{1,11960}$ = 38.70, p < 0.001). On the other hand, in the PM phase the fat stores do not differ between adults and juveniles. In the PM phase in each year and at both sites the body mass and fat score is higher than in the PB phase for both age groups (Ócsa and Izsák 2002: body mass: $F_{1,11796}$ = 133.35, p < 0.001; fat score: $F_{1,11960}$ = 899.29, p < 0.001; Izsák 2000–2002: body mass: $F_{1,18583}$ = 243.56, p < 0.001; fat score: $F_{1,18583}$ = 530.74, p<0.001).

EDFL compared to the western Mediterranean data

The EDFL values were different between the two sites (*t*-test in each case p < 0.05). The average body mass, fat score and EDFL value at Izsák in the PM phase for both age groups is equivalent to the data from Spain (*t*-test in each case NS) and significantly smaller than the data from Italy (*t*-test for each comparison p < 0.05). Our study sites are at a minimum 600 km farther from the distant end of the geographical barriers (Mediterranean Sea, Sahara desert) as opposed to the Spanish and Italian sites (Table 1).

Table 1. Average body mass, fat score and Estimated Departure Fuel Load value of Barn Swallows at the study sites of Ócsa and Izsák compared to the same parameters in Italy and Spain from the study of RUBOLINI *et al*. (2002). S.D. and n are in paranthesis.

Geographical area	Body mass	Fat score	EDFL
Italy, adult	22.5 (2.5; 858)	4.1 (1.1; 869)	43.8 (6.2; 220)
Italy, juvenile	21.1 (2.3; 4925)	3.9 (1.1; 4927)	35.7 (5.8;1233)
Spain, adult	21.1 (2.3; 320)	3.2 (1.4; 322)	33.9 (5.7; 80)
Spain, juvenile	19.6 (2.1; 3101)	2.9 (1.3; 3099)	24.6 (6.5; 841)
Hungary			
Ócsa, adult	19.9 (1.8; 734)	2.2 (1.4;742)	24.5 (5; 184)
Ócsa, juvenile	19.1 (1.7;2654)	2.1 (1.4;2800)	19.4 (5.4;663)
Izsák, adult	21.1 (2.1; 666)	3.4 (1.5;662)	33.3 (6.4;167)
Izsák, juvenile	20.2 (2.2;2859)	3.1 (1.4;2857)	29.5 (7.7;715)

Recaptures between the two study sites

There were exchanges between the two roosting sites during autumn migration when 2 birds moved from Ócsa to Izsák and 4 birds in the other direction in 2002. This kind of exchange of birds between the two sites is observable in every other year, as well.

Recoveries

More than 311000 Barn Swallows were ringed in Hungary between 1951–2005. Onehundred-eighteen of these birds were recovered abroad, which is a very low 0.0004% recovery rate. During autumn migration birds have been recovered south of Hungary within the eastern and central regions of the Mediterraneum (Table 2).

During the EURING swallow project in Italy 374000 Barn Swallows were ringed, most of them on roost in autumn. During the same period in Hungary 167000 swallows were ringed and from among these only 1 was recaptured in Italy in autumn.

In the spring period there have been recoveries from different parts of the entire Mediterranean basin ranging from Spain through Italy to Turkey (Table 2). In the eastern part of the Mediterranean ringing activity is very low and mostly con-

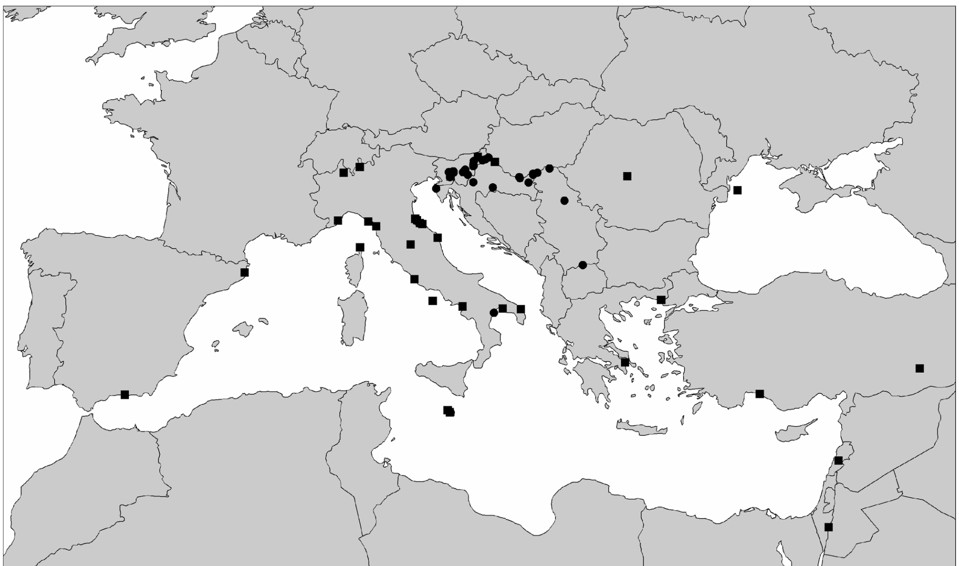

Fig. 6. Map of recoveries south from Hungary in Europe during autumn (July–November, circles) and spring (March–May, squares)

centrated on spring migration. During the autumn migration period the earliest birds arrive in Sub-Saharan Africa already in September and these fastest birds demonstrate that they are able to cover this 4–5000 km distance in 25–35 days, translating to an average of 140–170 km distance covered per day of travel.

Table 2. Number of Barn Swallows by country ringed in Hungary or abroad and recaptured during autumn or spring migration period separately (1951–2005)

	Ringed in Hungary			Ringed abroad		
	Autumn (Aug.–Oct.)	Spring (Mar.–May)	Winter	Autumn (Aug.–Oct.)	Spring (Mar.–May)	Winter
Balkan Peninsula						
Croatia	3	1		10		
Serbia	3	7				
Slovenia	4	2		22		
Western Mediterranean						
Italy	1	7			14	
Spain					2	
Malta	1	5				
Eastern Mediterranean						
Greece		5				
Turkey		4			2	
Israel		1				
Lebanon		1				
Africa						
South Africa	1					
Democratic Republic of Congo	5	1				1
Central African Republic	4		14			
Kenya		1				
Lesotho			1			
Botswana						2
Nigeria	1		3			
Zambia			1			
Chad	1					

Flight ranges

PILASTRO and SPINA (1999) calculated flight ranges of swallows with different fat loads. According to their model a bird with 22 g body mass holding approximately 4.2 g fat reserves can cover a distance of 2300 km, while one with a 25 g body mass and an estimated 7.2 g fat load can cover 3700 km. In our database, 15.8% of the birds in the PM period were found to be heavier then 22 g and only 1.4% of the birds was heavier than 25 g.

Theoretical flight ranges were estimated for Barn Swallows based on the parameters from the study of PENNYCUICK *et al.* (2000). Based on the model a bird with a body weight of 19.5 g can cover 1800 km and one with 24.5 g can cover 3600 km. In our sample, 50.4% of the birds were heavier than 19.5 g and 3.7% of the birds were heavier than 22 g. This suggests that based on the two different flight range calculations 15.8–50.4% of the birds from Hungary could reach the southern coast of the Mediterranean while an estimated 1.4–3.7% could reach the southern part of the Sahara.

DISCUSSION

In this study we investigated two stopover sites in Hungary which are connected during autumn migration. The data show that there are differences in the condition (body mass, fat categories) and the size (wing length) of birds between the two sites, indicating that Izsák provides better conditions for fat accumulation. Accordingly, birds at this site had longer wing lengths.

The fattening of the swallow is very much dependent on the weather. This species is an aerial feeder and forages on flying insects, which are inaccessible in rainy and cold weather conditions, thus during periods of relatively poor weather the overall condition of birds can decline rapidly (ORMEROD 1991, PILASTRO & MAGNANI 1997). At our two study sites in 2002, these fluctuations in body mass occurred in parallel and the differences observed were identical between average body mass and fat scores. This pattern suggests that the parallel fluctuation was inflicted by similar weather at the two sites. The constant difference in body mass again indicates that Izsák is a more optimal habitat for swallows during autumn migration for gaining fat. The differences between the average wing length at the two sites in addition suggests that larger birds tend to use the more optimal stopover habitat during their migration.

Optimality models of bird migration are based on optimal choices during the migration: habitat/stopover site choice, timing, fat storage (ALERSTAM & LINDSTRÖM 1990). Individuals with better quality usually able to utilize and take control of better resources. In our case we indeed found that on average better quality individuals used the better feeding area in a system of interconnected stopover sites. The mechanism which generates this pattern is unknown and requires further investigation. The differences of body mass and fat scores between age groups and different migration periods, revealed analogous patterns to studies performed in other parts of Europe. The adult birds were heavier than juveniles in each instance, which is not surprising since they are larger with a longer wing and tail. Fat reserves are larger for juveniles during the PB phase, although there is no difference during the PM phase. Both age groups hold larger fat stores during the PM phase than the PB phase. These findings are similar to those in other parts of Europe (RUBOLINI *et al.* 2002)

At Izsák, Lake Kolon in the three consecutive autumn migration seasons of observation, significant differences were found between years in body mass and fat score. This suggests that fat accumulation potential and therefore flight range capacity can fluctuate year by year. Based on these findings, comparisons of data from over several years and different sample sizes could yield misinterpretation of flight range differences between sites.

Previous analyses of Barn Swallow body mass variation across Europe have indicated that important fuelling areas are located around the Mediterranean, particularly in Italy and Iberia (PILASTRO & SPINA 1999, RUBOLINI *et al.* 2002). These areas host the last stopover sites before the critical journey across the ecological barriers represented by the Mediterranean Sea and the Sahara desert. Western European populations leave the breeding grounds in continental and northern Europe with fairly low energy stores, complete their post-breeding and post-juvenile body moult during the earlier part of the trip, reach the main fattening areas of southern Europe during August and then, after completion of the body moult, start to gain weight rapidly followed by departure for the African wintering grounds in September (PILASTRO & MAGNANI 1997, PILASTRO & SPINA 1999). On the other hand, currently no information available on of the existence of similar stopover sites in the Eastern Mediterranean area. Birds ringed during the breeding season or at roosting sites during migration in Hungary have been so far recovered during August-October only from short distances in Slovenia, Croatia, Serbia, Macedonia with only 1 recovery from Italy and 1 from Malta in the late period of migration in October. Conversely, during spring migration there have been recoveries from the entire range of the Mediterranean basin from Spain in the west to Lebanon in the east. This shows a distinctly different migration route and strategy during autumn and spring. The different migration routes used during autumn and spring are true for British Barn Swallows as well, which migrate further east during spring than in the autumn (WERNHAM *et al.* 2002).

Understanding the different patterns in ringing activity among different parts of the Mediterranean it appears very likely that the birds do not utilize stopover sites in the western and central part of the Mediterranean during fall migration, while they clearly use these sites during spring. In the eastern part of the Mediteranean all the recoveries are linked to high-effort spring ringing activities, but in autumn there is minimal ringing activity in Greece and Turkey, leading to an extremely low chance for recoveries. The differences in ringing activity between countries can yield a very different picture from reality as reported by SZÉP *et al.* (2006) in their report on the identification of winter quarters of different Barn Swallow populations.

In this study we showed that swallows accumulate a similar amount of fat in Hungary as in Spain, but based on theoretical flight range calculations such fat reserves should enable the birds only to crossing the Mediterranean, but not the Sahara desert. On the other hand, the recoveries suggest that the fastest birds can reach sub-Saharan Africa in 25–35 days, which leads to the presumption of either a non-stop migration or at most very short stopovers given the timeframe.

From our data we can conclude that the birds in all likelihood cannot migrate from Hungary directly to Sub-Saharan Africa. At a minimum, they have to maintain the fat reserves accumulated in Hungary or potentially build some more fat stores until they reach a closer point where they can start the barrier crossing.

These findings can provide the foundation to the following conclusions which need further studies for clarification:

(1) The Barn Swallows breeding in or migrating through the Carpathian basin migrate via the eastern part of the Mediterranean and there are important refuelling areas to be uncovered.

(2) The optimalization of fattening of Barn Swallow is not exactly meeting the theory presented by ORMEROD (1991) "migrating with low fat deposit and refuelling during migration" nor the theory of RUBOLINI *et al.* (2002) "refuelling before ecological barriers and crossing them with a high fat deposit". The Barn Swallows breeding in or migrating through the Carpathian Basin use the inland wetlands to build medium-high fat deposits and refuel gradually during migration.

In order to clarify these options more effort should be taken to conduct research in the eastern parts of the Mediterranean area to find potentially important refuelling areas for the migration of swallows.

The population of Barn Swallows and other farmland birds has been declining over large regions of Europe with such shifts being closely connected to changes in land usage and changing agricultural practices (BirdLife/EBCC 2004, GREGORY *et al.* 2004, MARCHANT 1992). For long distance migrants the state of stopover areas during migration and the quality of wintering habitats has also proved to be crucial and plays an important role in controlling annual survival and even the reproduction rate and quality of offspring in the subsequent breeding season (NEWTON 2004, GREENBERG & MARRA 2005). Thus, better understanding of important stopover sites in the eastern part of the Mediterranean is essential for an effective conservation strategy for long-distance migrant farmland birds.

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Amphistomes of the World
A check-list of the amphistomes of vertebrates

O. Sey

The amphistomes are one of the rare groups of digenetic trematodes which have a broad spectra of the definitive hosts together with a wide geographical distribution, forming a continuous evolutional lineage from fishes to mammals. At the same time, some species of them are causative agents of devastating disease of domestic and wild animals, mainly ruminants. Therefore, amphistomes may have professional and practical interests for research and thus a great number of information has been accumulated on their classification and biology. The intention of this check-list is to bring together a comprehensive list of the amphistomes, presently known and sources of references of their hosts and geographic distribution (87 pages). This list consists of three main parts. In the first "Parasite/host check-list" (137 pages), parasites were listed under their scientific names, followed by the synonyms, then the name of the authorship as well as the name of the countries from which they were reported. In the second "General host/parasites check-list" (31 pages), host were listed systematically under their scientific names from fishes to mammals, followed by amphistomes described in them in alphabetical order. In the third "Host/parasites check-list by countries" (63 pages), countries were listed alphabetically, hosts systematically and their parasites alphabetically. When it seemed to be necessary some comments were given and they are found in Chapter 7 "Notes" (5 pages). Three indexes (parasite, host and countries) are added to the list (29 pages).

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