

MIGRATION OF CENTRAL AND EAST EUROPEAN *Acrocephalus* WARBLERS AT THE EASTERN ADRIATIC COAST: AN ANALYSIS OF RECOVERIES

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ABSTRACT

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Migration routes and origins of the Reed Warbler (*Acrocephalus scirpaceus*), Great Reed Warbler (*A. arundinaceus*) and Sedge Warbler (*A. schoenobaenus*) populations migrating through the eastern Adriatic coast were investigated by analysing recoveries of birds ringed or found at two eastern Adriatic wetlands during autumn migration. There were 75, 104 and 63 long-distance recoveries for these three species, respectively. Great Reed Warblers from central and eastern Europe and Sedge Warblers from countries surrounding the Baltic Sea use the eastern Adriatic wetlands as stopover sites and continue their migration across the Mediterranean. Some Great Reed Warblers use south-western route during their return migration. Reed Warblers of unknown origin, presumably from eastern Europe continue their migration through south-western route to Spain (mean distance – 1329.3 ± 118.0 km, $n = 20$; mean azimuth – $251.05 \pm 4.91^\circ$, $n = 20$; mean velocity – 63.25 km/day, $n = 16$). Local breeding Reed Warblers migrate southeast along the eastern Mediterranean (azimuth 117.53°). Eastern Adriatic coast represents a crossroads for migratory warblers using south-western, south-eastern and central Mediterranean flyways.

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INTRODUCTION

Three species of *Acrocephalus* warblers: Reed Warbler (*Acrocephalus scirpaceus*), Great Reed Warbler (*A. arundinaceus*) and Sedge Warbler (*A. schoenobaenus*) are widely distributed in Europe. The Sedge Warbler's range extends from boreal through temperate zone and only marginally to Mediterranean zone, while the other two species breed in middle latitudes of western Palearctic including the Mediterranean. All three species breed predominantly in lowlands. Reed Warblers and Great Reed Warblers are mostly concentrated in aquatic vegetation emerging

from shallow standing water, especially in reedbeds, while Sedge Warblers breed in wide variety of low dense vegetation and are less closely linked to lakesides and wetlands. All of them are long-distance migrants, wintering in sub-Saharan Africa (Cramp 1992). Eastern European and Finnish Sedge Warblers and eastern European Great Reed Warblers winter in eastern and central Africa, while western European populations of these species winter in tropical West Africa (Hagemeijer and Blair 1997). Sedge Warblers and Great Reed Warblers often migrate on a broad front through the Mediterranean, with recoveries in Malta, Cyprus and southern Italy (Zink 1973, Cramp 1992), while Reed Warblers show a migration divide (Berthold 2001). They apparently avoid crossing the Alps, central Mediterranean and the central Saharan desert and use either south-western or south-eastern route. The south-western flyway is used by central and west European Reed Warblers, migrating through France and Spain to West Africa. The south-eastern flyway is used by Reed Warblers from eastern Austria (Neusiedler See), adjacent areas of Hungary, south-eastern Czech Republic (Cramp 1992, Hagemeijer and Blair 1997) and probably northern Serbia (Novčić and Hulo 2005). Those birds migrate through the Balkans, western Turkey, Cyprus, Egypt and Sudan (Cramp 1992). The third, central Mediterranean flyway passes through Italy, Sicily and Malta to Tunisia. Croatia represents a crossroads for migratory birds using south-western, south-eastern and central Mediterranean flyways. The goal of this study is to analyse movements of *Acrocephalus* warblers through Croatian coast during autumn migration.

METHODS AND STUDY AREA

The eastern Adriatic coast is a karstic area with only a few bigger wetlands. These wetlands therefore represent very important stopover sites for many migratory birds. In the central part of the Croatian coast, intensive ringing during autumn migration was conducted at two wetlands: Lake Vransko and Kolansko Blato.

Lake Vransko is situated on the eastern Adriatic coast near Biograd (43°56'N, 15°31'E – 43°51'N, 15°39'E), close to the coastline. It is the largest natural lake in Croatia with surface area of 30.7 km² (13.6 km long and 1.4-3.4 km wide). The water is shallow – from 1 m (in the northern part) to 6 m (in the southern part). A narrow reed belt surrounds almost entire lake, but in the northern part there is a large reedbed, which is protected as a special ornithological reserve. The whole area is protected as a Nature Park (57 km²). Kolansko Blato (44°30'N, 14°58'E) is a small freshwater wetland on the island of Pag. Its area of 5.25 km² is protected as a special ornithological reserve. As the result of eutrofication, the reedbed covers the majority of the site.

Birds were ringed during autumn migration at both sites for several decades, but intensive ringing took place from 2001 to 2005. In these years, the summer ringing camp at Lake Vransko was organized. The ringing commonly started in late July or early August and lasted 30-54 days. Exceptionally, in 2005 it lasted 103 days, until the end of October. In this period, ringing at Kolansko Blato was also more inten-

sive than in previous years. The three *Acrocephalus* warblers were among the most numerous species ringed.

In the analysis, all historical recoveries from Lake Vransko and Kolansko Blato were taken into account, excluding local recoveries (birds ringed and recovered at the same place). In total, 242 ringing recoveries of 232 birds ringed or recovered at the central Croatian coast (Lake Vransko and Kolansko Blato) were analysed. Out of them 107 (28 Great Reed Warblers, 18 Sedge Warblers and 61 Reed Warblers) were ringed at the central Croatian coast, while 125 (70 Great Reed Warblers, 43 Sedge Warblers and 12 Reed Warblers) were ringed abroad and recovered at the central Croatian coast.

The loxodromic distance and direction of movements were calculated according to Imboden and Imboden (1972). The mean angle was calculated according to Zar (1974). The significance of the differences between means was tested with Mann-Whitney *U*-test for linear data (*i.e.* distance) and Watson's U^2 -test for circular data (*i.e.* direction). Cases were considered to indicate breeding when a bird was ringed as pullus, ringed/recovered as breeding bird (status given in reporting letter from the Ringing Scheme) or ringed/recovered during breeding period (according to Cramp 1992) *i.e.* from 20 May to the end of July (until 15 July for the Reed Warbler). The majority of recoveries belonged to the first-year birds, so generally, it was not possible to distinguish migration strategies of first-year and adult birds.

RESULTS

Ringing totals for the period of 2001 to 2005 at Lake Vransko and Kolansko Blato were 9785 Great Reed Warblers, 11 162 Sedge Warblers and 27 879 Reed Warblers. There were 104, 63 and 75 long-distance recoveries for these three species, respectively (Table 1).

For the Great Reed Warbler a total of 104 recoveries from 98 birds were analysed (Fig. 1), 41 of them ringed or subsequently recovered during the breeding period. Birds migrating along the central Croatian coast were breeding in central and eastern Europe: SW Poland (12 recoveries), eastern part of Germany (16 recoveries), Czech Republic (7 recoveries), Slovenia, Hungary, Belarus, Lithuania and Russia. To reach the eastern Adriatic coast they headed between SE and SW (range – 141.0–223.4°, mean – 183.91 ± 17.1°, $n = 41$). Only twelve recoveries showed further movements of birds, after leaving the central Croatian coast. Among them, there were five direct recoveries. Birds were found on Slovenian and Croatian coast north of the ringing place, 4–14 days after being ringed (mean distance – 194.5 ± 8.9 km; mean azimuth – 323.47 ± 2.0°), thus they did a reversed migratory step. Recoveries in central and southern Italy and Malta confirm that Great Reed Warblers migrate across the Mediterranean, but spring recoveries from France (Corsica) and Spain suggest that some birds use the south-western flyway during prenuptial migration.

Table 1

Numbers of long-distance recoveries for three *Acrocephalus* warblers ringed in foreign countries and recovered at the central Croatian coast ("ringed") and ringed at the central Croatian coast and recovered in foreign countries ("recovered")

Country	<i>A. arundinaceus</i>		<i>A. schoenobaenus</i>		<i>A. scirpaceus</i>	
	ringed	recovered	ringed	recovered	ringed	recovered
Austria	1	-	-	-	-	-
Belarus	1	-	-	-	-	-
Croatia	-	2	-	1	-	6
Czech Rep.	13	4	4	2	3	-
Denmark	-	-	-	1	-	-
Estonia	2	-	2	-	-	-
Finland	-	-	7	-	-	-
France	-	1	-	-	-	3
Germany	16	2	1	1	-	-
Greece	-	-	-	1	-	-
Hungary	11	2	5	6	1	3
Italy	2	3	2	2	2	6
Lithuania	2	1	2	-	-	-
Malta	1	-	-	-	1	-
Mauritania	-	-	-	-	-	3
Poland	9	10	-	1	-	-
Portugal	-	-	-	-	-	1
Russia	1	-	-	-	-	-
Serbia	1	-	-	-	-	-
Slovakia	-	-	-	-	-	1
Slovenia	9	9	6	4	3	20
Spain	1	-	-	-	-	20
Sweden	-	-	14	1	-	-
Switzerland	-	-	-	-	1	-
Ukraine	-	-	-	-	1	-
Total	70	34	43	20	12	63

For the Sedge Warbler a total of 63 recoveries of 61 birds were analysed (Fig. 2), 9 of them indicating breeding. Breeding birds originated from countries surrounding the Baltic Sea: southern Finland, southern Sweden, Lithuania and NE Germany, but also from the Czech Republic. These birds were heading between SSE and SSW (range -168.6 - 197.4° , mean $-183.97 \pm 8.9^\circ$, $n = 9$). Especially numerous were the recoveries of non-breeding birds from Sweden. Only ten recoveries showed further movement of birds. There were three direct recoveries in Slovenia of birds leaving central Croatian coast, between 2 and 10 days after being ringed (mean distance -244.9 ± 27.1 km, mean azimuth $350.98 \pm 21.13^\circ$). Another four birds were found in central and southern Italy, indicating migration across the Mediterranean. One adult bird was found in Greece, 20 days after being ringed. One first-year Sedge Warbler was found in NW Croatia 5 days after being ringed at Lake Vransko during autumn migration:

HRZ BB54229

2 Sept. 2002 Lake Vransko, Pakoštane, HR (43°53'N, 15°33'E)

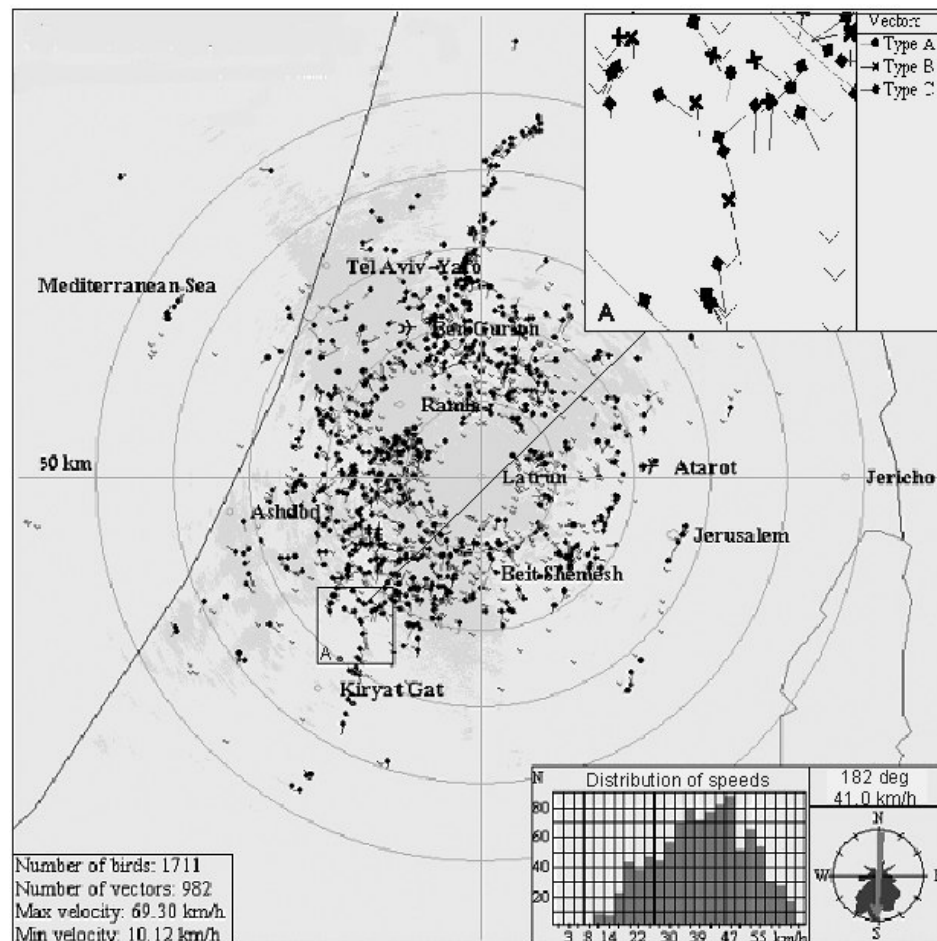
7 Sept. 2002 Draganić fishp., Karlovac, HR (45°34'N, 15°38'E)
controlled 187 km N

Fig. 1. Ringing/recovery sites of Great Reed Warblers (*Acrocephalus arundinaceus*) migrating through the eastern Adriatic coast. Upper panel: during breeding time (black dots), lower panel: during migration time (circles); big signs – several recoveries (given number) in one or close locations.

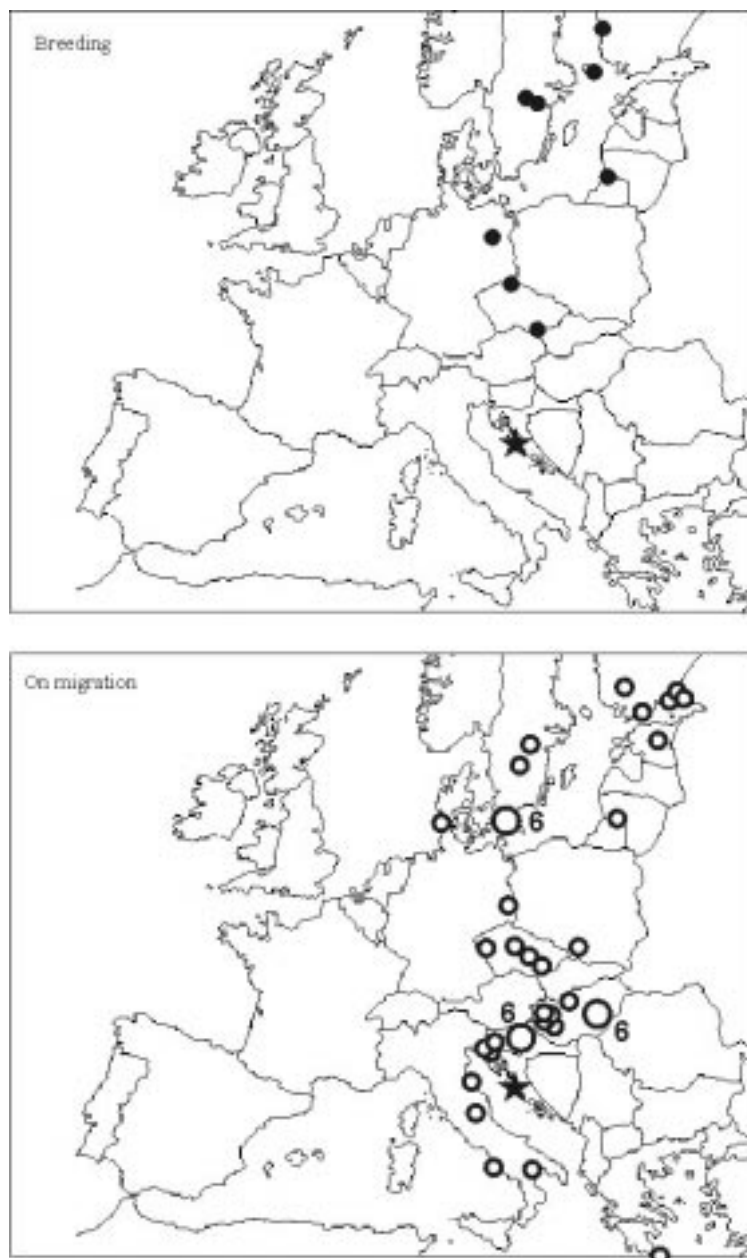


Fig. 2. Ringing/recovery sites of Sedge Warblers (*Acrocephalus schoeobaenus*) migrating through the eastern Adriatic coast. Upper panel: during breeding time (black dots), lower panel: during migration time (circles); big signs – several recoveries (given number) in one or close locations.

For the Reed Warbler a total of 75 recoveries from 73 birds were analysed (Fig 3). There were no recoveries that would indicate breeding origin of birds. Birds recovered at the Croatian coast were ringed during autumn migration in the same

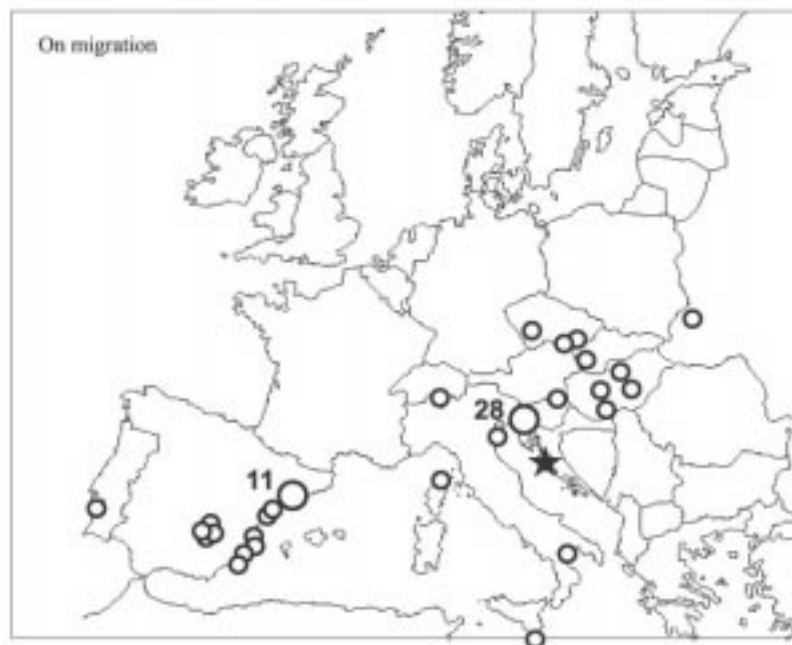


Fig. 3. Ringing/recovery sites of Reed Warblers (*Acrocephalus scirpaceus*) migrating through the eastern Adriatic coast during migration time (circles); big signs – several recoveries (given number) in one or close locations. There were no recoveries/rings during breeding period.

season in Hungary, the Czech Republic and Ukraine. Elapsed time was 6 days for one bird from Hungary, 18 days for one bird from Ukraine and 24-43 days for three birds from the Czech Republic. Recoveries of birds leaving the Croatian coast were numerous. There were 44 direct recoveries from 42 birds leaving central Croatian coast, the majority on the south-western route (mean azimuth – $286.56 \pm 57.7^\circ$, $n = 44$). Recoveries from Slovenia were numerous, with first birds found on the very next day. Two birds were found in NE Italy after three days. Eighteen Reed Warblers (20 recoveries, 16 direct recoveries) were found between August and October (one in May) in Spain, the first one only 7 days after being ringed (mean distance – 1329.3 ± 118.0 km, $n = 20$; mean azimuth – $251.05 \pm 4.91^\circ$, $n = 20$; mean velocity – 63.25 km/day, $n = 16$). There were no significant difference between distance and azimuth of first-year and older birds (distance – Mann-Whitney U -test: $z = 1.22$, $p = 0.22$; azimuth – Watson's U^2 -test: $U = 0.082$, $p > 0.2$). One bird was found in October in Portugal and three birds during September and October in Mauritania. These recoveries show that Reed Warblers migrating along the south-western route initially fly NW to Slovenia and north-eastern Italy and then (probably through the river Po valley and southern France) to Iberian Peninsula. Two birds, ringed in mid-July (local breeding birds) were found 23 days later at the Neretva delta, in south Dalmatia (distance – 190 km, azimuth – 117.53°), indicating the use of south-eastern migratory route by local birds. There were three direct recoveries of birds

ringed during autumn migration in NE Italy and NW Slovenia, found 8-10 days later at Lake Vransko (mean distance – 244.3 ± 16.2 km, mean azimuth – $142.32 \pm 0.23^\circ$).

DISCUSSION

For the Great Reed Warbler and the Sedge Warbler there were more recoveries showing the origin of birds than those indicating the direction of further migration, contrary to the Reed Warblers. Recoveries suggest that Great Reed Warblers migrating through the eastern Adriatic coast originated from central and eastern Europe, while Sedge Warblers originated from countries surrounding the Baltic Sea. The number of recoveries showing the direction of further migration for these two species was low, only 11.5% of all recoveries for the Great Reed Warbler and 14.3% in the case of Sedge Warblers. Both species apparently cross the Mediterranean on a broad front, with eastern Adriatic wetlands being on their route (Zink 1973, Cramp 1992). Great Reed Warblers from Latvia, Poland, East Germany, Hungary and Austria were recorded in Malta (Sultana and Gauci 1984/1985, Cramp 1992), eastern Austrian birds were recorded in eastern Algeria and Tunisia (Schlenker 1986) and those from the Czech Republic and Slovakia – in Italy and Tunisia (Procházka and Reif 2000). Similarly, Sedge Warblers from Finland (Koskimies and Saurola 1985), Sweden (Fransson *et al.* 2001, Fransson *et al.* 2003), the Czech Republic and Slovakia (Procházka and Reif 2002) were found in Slovenia, Croatia, Italy, Malta, Algeria and Egypt.

Great Reed Warblers and Sedge Warblers migrating through the eastern Adriatic continue their migration over the Mediterranean. This is confirmed by recoveries from central and southern Italy and Malta, but number of these recoveries is very small – only four per species. Reaching eastern Mediterranean, they can use three possible routes: along the coast towards NW or SE, or over the Adriatic Sea. Direct recoveries of three Sedge Warblers and five Great Reed Warblers in NW Slovenia and NE Italy suggest reversed migration after having faced the sea, but the ratio of direct recoveries between Croatian ringing sites and ringing sites in NW Slovenia and NE Italy was roughly the same for birds moving towards NW and towards SE. Although some of the recoveries from early August may represent pre-migratory dispersal movements (Berthold 2001, Mukhin 2004), other recoveries occurred in late August and early September and distance between two sites was rather long: 235 km. Small number of direct recoveries for these two species in Slovenia and NE Italy compared to the number of recoveries of the Reed Warbler in the same area indicate that the majority of Sedge Warblers and Great Reed Warblers fly across the Adriatic Sea, not around it.

Two recoveries (from Spain and Corsica) of Great Reed Warblers captured in May indicate that some birds migrating through the central Adriatic use south-western route during spring migration. The use of south-western route during pre-nuptial migration is further confirmed with two Hungarian (Karcza pers. comm.) and one Czech recovery (Procházka and Reif 2000) of this species.

The number of the Reed Warbler recoveries showing the direction of subsequent migration is very high (70.6% from all recoveries). It seems that after leaving stopover sites at the Croatian coast, birds were heading NW to Slovenia (in order to avoid crossing the Adriatic Sea), then turned W across northern Italy and south France to Spain, from where they flew through Mauritania to their wintering areas. But, contrary to the other two species, breeding origin of these birds remains unknown since all recovered birds were ringed during autumn migration, from mid-July to early September. The scarcity of foreign recoveries of this numerous reed-bed species indicates that Reed Warblers from countries with intensive ringing (northern and central Europe) apparently bypass the Croatian coast. Birds using south-western route mainly pass north of the Alps (Zink 1973, Literák *et al.* 1995), while these breeding southeast of the migratory divide (Hungary, eastern Austria, south-eastern Czech Republic and northern Serbia) use the south-eastern flyway, across the Balkans and western Turkey (Cramp 1992). Reed Warblers migrating through Hungary use both the south-eastern (through Greece and Turkey) and south-western route (Simon 2002, Halmos *et al.* 2003, Gyurácz *et al.* 2004, Halmos and Karcza 2004). However, a recovery of a first-year bird ringed in Cholgyni ringing station in Ukraine caught 18 days later at Lake Vransko and a Slovenian recovery of a Reed Warbler ringed as pullus in Belarus (Šere pers. comm.) show that some birds from eastern Europe migrate also towards SW:

UKK B 024168 *imm.*

4 Aug. 2003 Cholgyni, L'viv prov., UA (49°58'N, 23°28'E)

22 Aug. 2003 Lake Vransko, Pakoštane, HR (43°53'N, 15°33'E)

BYM KA 08237 *pull.*

19 Jun. 2000 Beloye fishp., Gomel distr., BY (52°18'N, 27°39'E)

18 Aug. 2002 Dolenje jez., Cerkniško jez., SI (45°46'N, 14°22'E)

controlled 1207 km SW

This is further confirmed by orientation tests of Reed Warblers from Ukraine, with the high percentage of birds that head westwards during autumn migration (Trocińska *et al.* 2001). It is possible that these birds fly toward the Adriatic Sea, then turn north to Slovenia and northern Italy and continue their migration along the south-western route.

A small number of Reed Warblers also use central Mediterranean route (indicated by the recoveries of both adult and juvenile birds from Malta and southern Italy). One first-year Reed Warbler ringed in late July in eastern Slovenia was found 51 days later in Libya (Šere 1998). The possible use of that route by Reed Warblers is mentioned by Dowsett-Lemaire and Dowsett (1987). Although the majority of Reed Warblers migrate through eastern Croatian coast towards western Europe, those breeding at the central Croatian coast migrate southeast along the Adriatic coast, which was confirmed by two recoveries at Neretva delta (south Dalmatia). Direct recoveries of three birds from NE Italy and NW Slovenia to central Croatian coast indicate that some birds of more northern origin may also use this route.

The intensity of migration of *Acrocephalus* warblers along the eastern Adriatic coast towards SE is still unknown. A clear disproportion between number of recoveries of the Reed Warbler and other two species after leaving central Croatian coast may indicate that part of Great Reed Warblers and Sedge Warblers migrating along the eastern Adriatic coast enter the geographical area without high ringing activity (Albania, Greece). Croatian coast represents a crossroads for migratory birds using south-western, south-eastern and central Mediterranean flyways. Further study of directional preferences using orientation experiments and alternative approaches, e.g. stable isotopes and genetic markers (Webster *et al.* 2002) may shed light on the direction of birds migrating through the eastern Adriatic coast.

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