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DIE VOGELWELT

BEITRÄGE ZUR VOGELKUNDE

Aquatic Warbler – Seggenrohrsänger

World population, trends and conservation

Breeding system – a review of new results

Breeding habitat, abundance and conservation status in Belarus

Habitat selection in Poland: consequenses for conservation of the breeding areas

Population size and habitat in Hungary

Herausgeber:
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Foto auf dem Umschlag:
Seggenrohrsänger *Acrocephalus paludicola*
Foto: A. KOZULIN.

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Editorial

„Ein ganzes VOGELWELT-Heft voller englischer Beiträge – eine Zumutung!“ werden vielleicht einige von Ihnen denken. Vielleicht befällt einige Leser sogar die Befürchtung, die VOGELWELT könnte sich allmählich mehr und mehr in ein englischsprachiges Fachjournal verwandeln. Aber das ist nicht im geringsten geplant! Wir möchten hier gar nicht die bekannten allgemeinen Argumente bemühen, daß Englisch heute die internationale Wissenschaftssprache ist und deutschsprachige Veröffentlichungen in der internationalen Szene kaum noch Beachtung finden usw. Im Falle dieses Seggenrohrsänger-Heftes bot sich ausnahmsweise die Gelegenheit, ein ganzes Heft mit hochaktuellen internationalen Beiträgen zu einer global bedrohten deutschen Brutvogelart zu füllen – Beiträge, die größtenteils bisher unveröffentlichte, aktuelle Daten zur Verbreitung und zum Weltbestand des Seggenrohrsängers enthalten und teilweise sogar die Brutsaison 1998 mit berücksichtigen. In diesem Heft wird ein umfassendes und nahezu vollständiges Bild zur prekären Situation der Art präsentiert. Kaum einer der ganz überwiegend aus Osteuropa (Rußland, Weißrußland, Ukraine, Ungarn u.a.) stammenden Autoren spricht deutsch. Schon deshalb wäre eine deutschsprachige Veröffentlichung ihrer Beiträge weder sinnvoll noch praktikabel gewesen. Darüber hinaus sind wir jedoch sicher, daß das vorliegende Heft gerade auch im englischsprachigen Raum und in der internationalen Vogelschutzszene auf größtes Interesse stoßen wird. Nicht nur *BirdLife International*, *Wetlands International*, britische Förderer und Sponsoren osteuropäischer Forschungs- und Naturschutzprojekte (z. B. die britische *Darwin Initiative)* und die EU-Kommission haben an der hier vorgelegten Zusammenstellung starkes Interesse; auch in den Ländern Osteuropas können durch diese Publikationen durchaus naturschutzpolitische Entscheidungen nachhaltig beeinflußt werden.

Aus all diesen Gründen bestand kein Zweifel, daß, wenn wir die Chance wahrnehmen und diese Arbeiten in der VOGELWELT publizieren wollen, dies nur in englischer Sprache sinnvoll möglich ist. Anderenfalls hätten wir auf eine Publikation in Deutschland verzichten müssen – und das wäre doch schade, weil es um eine Art geht, die früher in vielen Teilen Deutschlands geradezu häufig war und, auch von uns Deutschen, in nur wenigen Jahrzehnten an den Rand des Aussterbens gebracht wurde. Damit die Lektüre des Heftes auch für den des Englischen unkundigen Leser informativ wird, haben wir für ausführliche deutsche Zusammenfassungen und Untertitel der Tabellen und Abbildungen sowie eine reiche Bebilderung gesorgt. So hoffen wir, daß eine breite Leserschaft Interesse an diesem Themenheft finden wird.

Martin Flade &
Andreas J. Helbig

Breeding Aquatic Warbler – Brütender Seggenrohrsänger. Foto: A. BALINSKI.

This special issue of "Die Vogelwelt – Beiträge zur Vogelkunde" is dedicated to our colleague and friend Prof. Dr. Andrzej Dyrcz, initiator and forerunner of the Aquatic Warbler research in the Polish Biebrza marshes, with cordial wishes for his 65th birthday.

Preface

The Aquatic Warbler *Acrocephalus paludicola*, which up to the mid-1990s was known as a breeding bird only from very few localities in the world, is the most threatened passerine bird species of continental Europe. It is classified as "vulnerable" at the global and as "endangered" at the European level. Despite these facts, and althought the breeding biology and the extraordinary mating system of the species have been intensively studied by a Polish-German research team for more than 15 years (see SCHULZE-HAGEN *et al.*, this issue), our knowledge about the world population size, distribution, population trend and current threats was surprisingly poor up to the early 1990s. But times are changing rapidly: We can now state that the Aquatic Warbler has developed from a fairly poorly known species to one of the best studied breeding birds in Europe. Knowledge especially about distribution, European range, habitat selection, diet, population size, trend and threats has increased drastically during the 1990s. These exciting developments are documented in this issue. A large part of the data presented has not been published before and represents the very recent situation of the species (data of the 1998 breeding saison are included), which has to be judged as absolutely critical from a conservation point of view.

Comprehensive survey, monitoring and conservation activities, which already existed in Poland and Hungary, were initiated in 1995/96 in Belarus, Ukraine, Russia and Lithuania, leading to the foundation of the "Aquatic Warbler Conservation Team" (AWCT) in 1998. The AWCT is a free expert group, which was established to elaborate a proposal for an update of the EU Aquatic Warbler Species Action Plan (see paper of AWCT in this issue). In the group, experts from all seven countries within the breeding range of the species are co-operating to exchange data, information and experiences (for details see "News" at the end of this issue). The AWCT is funded and supported by the *Royal Society for the Protection of Birds* and works under the auspices of *BirdLife International*.

But studying and protecting the Aquatic Warbler is more than caring about a small, poorly known bird: it is connected with its unique habitat, the European fen mires, their beautiful landscape and fascinating wildlife, and the whole problem of mire destruction, drainage, peat excavation, abandonning of traditional pastoral farming in huge areas, increasing economical and social problems in the rural regions of Central and Eastern Europe and finally with the emission of huge amounts of CO_2 into the atmosphere, contributing to the global problem of climate change.

Moreover, the fast development and intensive work of the past four years has changed the views of many of us. We learned, for instance, how poor our knowledge is about a key nature conservation issue right in the geographical center of Europe, how important and effective a small bird can be in helping to change non-sustainable land-use policies, and what the nearly hopeless problems are to find an unconspicuous warbler under field conditions in the endless expanses of Russia. But at the end, hopes are rising that this endangered species and its unique habitat can be saved for the future.

All of this was only possible thanks to the help of some very special colleagues: first, our "*malinki* drug" (little friend), the Aquatic Warbler, who brought us together and was the reason and flagship for all activities documented here; second, our "*bolshoj* drug", the German business man Michael Otto and his foundation for environmental protection, who funded all initial surveys as well as conservation and monitoring work, and was the forerunner for the growing group of sponsors and supporters, which include: The British Darwin Initiative, BirdLife/Vogelbescherming Nederland, The Royal Society for the Protection of Birds (RSPB), EURONATUR, the Ministry for Natural Resources and Environment Protection of the Republic of Belarus, the Danish government etc.; finally, not to be forgotten, our "*zholty* drug" (yellow friend), who helped us in our desperate defence against the innumerable army of mosquitos. We hope that this special issue of VOGELWELT will find the interest of a broad international readership.

*Martin Flade, Co-editor of "*DIE VOGELWELT – Beiträge zur Vogelkunde" *and chairman of the Aquatic Warbler Conservation Team.*

World population, trends and conservation status of the Aquatic Warbler *Acrocephalus paludicola*

Aquatic Warbler Conservation Team*

Aquatic Warbler Conservation Team 1999: World population, trends and conservation status of the Aquatic Warbler *Acrocephalus paludicola*. Vogelwelt 120: 65 – 85.

The Aquatic Warbler is a globally threatened species which breeds in Belarus, Germany, Hungary, Lithuania, Poland, Russia and Ukraine. The European population is estimated at 13,500-21,000 singing ♂ (1997/98), with major parts of the population in Belarus, Poland and Ukraine. It is possible that there exists another isolated population of several thousand birds (up to 22,000 birds or 11,000 ♂) in western Siberia, but reliable data are lacking at the moment. The Aquatic Warbler is a specialist of large open sedge and *Cladium* fen mires and has suffered a severe decline over its whole range due to habitat loss. Within the current core area in E-Poland and the Belarusian and Ukrainian Polessye, the area of suitable fen mires has declined by 80-90 % within the past 30 years. Currently the direct destruction of habitat has slowed down, but habitat loss due to vegetation succession caused by abandonment of traditional farming practices and alterations of the hydroregime is accelerating. The remaining Aquatic Warbler population is highly vulnerable due to its concentration in only a few large mire tracts. There are less than 40 permanent breeding areas with more than 10 singing ♂ each in the whole of Europe. The three river systems of upper Pripyat (40 %), Yaselda (22 %) and Biebrza/Narew (13 %) hold about 80 % of the European population. The populations of Pripyat and Yaselda have only been discovered in 1995-1996 at a stage, when mire destruction, drainage campaigns and habitat loss due to abandonment and succession were going on at high speed.

Key words: *Acrocephalus paludocola*, globally threatened species, world distribution, population trend, species conservation.

1. Introduction

Since the first Aquatic Warbler workshop in 1993 at Ruda Milicka (Poland), which worked out the basis for the first version of the BirdLife International Action Plan for the Aquatic Warbler (HEREDIA *et al.* 1996), knowledge about this species has increased dramatically. In 1995, a series of expeditions was initiated by M. FLADE to east-central and eastern Europe, beginning in Belarus and Ukraine, followed by Lithuania, Latvia and European Russia, to search for the last untouched fen mires and remaining populations of Aquatic Warbler. More than two thirds of the currently known world population has been discovered only during the past four years. In addition to the well known and comprehensive research in the Biebrza marshes in Poland during the past 20 years (DYRCZ 1993; DYRCZ & ZDUNEK 1993a,b; SCHULZE-HAGEN *et al.* 1989; 1993; 1995), intensive ecological research on the species has also been conducted in Belarus since 1996 by A. KOZULIN and co-workers (KOZULIN *et al.* 1998; KOZULIN & FLADE 1999; KOZULIN *et al.* in prep.). Furthermore, a new complete survey has been performed in Poland in 1997 (KROGULEC & KLOSKOWSKI 1998). Through this enormous increase of knowledge, a new, up-to-date status report on world distribution, population size, trends, and conservation status has become necessary and is presented here.

*) Martin FLADE (chairman, Germany), Benedikt GIESSING (Germany), Igor GORBAN (Ukraine), Mikhail KALYAKIN (Russia), Oskars KEIŠS (Latvia), Janusz KŁOSKOWSKI (Poland), Gabor KOVÁCS (Hungary), Alexander KOZULIN (Belarus), Jaroslav KROGULEC (Poland), Anatoly POLUDA (Ukraine), Zydrunas PREIKSA (Lithuania), Norbert SCHÄFFER (United Kingdom), Karl SCHULZE-HAGEN (Germany), Alexander TISHECHKIN (Belarus), Zsolt VÉGVÁRI (Hungary), Alexander VINCHEVSKI (Belarus).

This paper is largely based on a workshop which took place in Brodowin, Germany, from 30 March to 1 April 1998 and which was appointed to update the *BirdLife International* Aquatic Warbler Action Plan from 1995 (HEREDIA *et al.* 1996). The Workshop was funded by the *Royal Society for the Protection of Birds* (RSPB).

2. Biological and ecological characteristics, habitat requirements

The Aquatic Warbler has an extraordinary breeding system with uniparental care by the ♀ and a mating system varying between promiscuity and polygyny characterised by intense sperm competition. About 59 % of broods are fathered by more than one ♂. The males, emancipated from almost all parental duties, sing and advertise throughout the whole reproductive season between early May and late July. Their home ranges average c. 8 ha, have a core area of c. 1 ha and overlap widely. Nests are built on the ground under dry sedges. Nesting aggregations can be found at sites of high productivity of arthropods. The diet comprises mostly large arthropods of the fen mires, Arachnida, Diptera, Lepidoptera (often caterpillars), and Trichoptera forming about 70 % of prey. Further characteristics and details of behaviour and breeding biology of the species are summarized by SCHULZE-HAGEN *et al.* (1999, this issue).

The Aquatic Warbler is a habitat specialist. During the breeding season it occurs mainly in sedge fen mires and similarly structured marshy habitats with a preferred water depth of 1-10 cm. In primeval landscapes without human (agricultural) impact it probably depends on mesotrophic or slightly eutrophic floodplain fen mires which do not overgrow because of regular flooding and the up-and-down movements of the surface, which is oscillating in parallel with the river water table.

Recently, Aquatic Warblers have been recorded mainly in five habitat types:

1. Rich floodplain marshes in river valleys comprising open sedge marshes with medium and large tuft-forming and scattered *Carex* (e.g. Biebrza and lower Odra river marshes in Poland, upper Ukrainian Pripyat), partly with taller *Molinia caerulea* or scattered low stems of *Phragmites australis*, and often also scattered bushes, which all serve as singing posts for the ♂. This type of habitat depends more or less on human agricultural use or management (periodical cutting or burning, sometimes extensive grazing).
2. Mesotrophic or slightly eutrophic open sedge fen mires with the ground covered by green mosses. The grassy vegetation is dominated by low or medium, partly tuft-forming sedges, shallow water or wet, water-saturated pillows of mosses (Dikoe and Yaselda, Zvanets and upper Pripyat marshes, Udaj, Supoj, Biebrza). Aquatic Warblers avoid poor mire tracts with *Sphagnum* mosses and *Eriophorum vaginatum*, as well as parts where water is too deep, bushes or reeds are too dense and tall, or where sedge tussocks are too tall.
3. Calcareous marshes with *Cladium mariscus* (Chelm marshes, Poland).
4. Seasonally flooded brackish marshes of the Baltic Sea coast characterised by very weak and low reed stands 80-120 cm high in summer (in Germany, Swina river mouth in Poland, along the Curonian lagoon/Nemunas river mouth in Lithuania).
5. Wet marshy grasslands covered by high grass and clumps of sedge (in Hungary and in the Narew valley in Poland).

Detailed information about the structure of breeding habitats is given in this issue by KOZULIN & FLADE (1999) for Belarus/Ukraine, KLOSKOWSKI & KROGULEC (1999) for Poland and KOVACS & VÉGVÁRI (1999) for Hungary.

During migration, Aquatic Warblers strongly favour low stands of sedges and reeds near open water, normally along rivers, estuaries and coastal lagoons (DE BY 1990). The habitat in winter is thought to resemble that of the breeding grounds, including *Salicornia* associations, large inundated grasslands and reed beds, etc. (SCHULZE-HAGEN 1993).

3. World distribution, population size, trend and threats

3.1. Breeding population size and distribution

The breeding range is restricted to the western Palearctic between 47° and 59 °N, although the range in Russia is not well known. Breeding occurs in Germany, Poland, Hungary, Lithuania, Belarus, Ukraine and Russia. Possible breeding in Latvia, Romania and Bulgaria has not been confirmed for the past 40 years.

The breeding distribution is fragmented because of habitat constraints. The species became extinct in western Europe during the 20th century and has declined dramatically in central Europe. It formerly bred in France, Belgium, Netherlands, former West Germany, Latvia, former Czechoslovakia, former Yugoslavia, Austria and Italy (SCHULZE-HAGEN 1991; CRAMP 1992).

Population figures are given in Table 1. The table shows the immense increase of knowledge in comparison with the publication of TUCKER & HEATH (1994). Table 1 also indicates that in countries were survey data existed in the early 1990s, the counts from recent surveys are lower, indicating an ongoing decrease (Poland, Germany). Only the Hungarian population has increased. Tab. 1 and Fig. 1 illustrate that – excluding the hypothetical west-Siberian population – about 60 % of the known world population is concentrated in Belarus, while more than 90 % are concentrated in only three countries!

3.2. Migration and wintering

Aquatic Warblers have been recorded on migration in 13 European countries. In autumn, birds from Poland, eastern Germany, and probably the whole Bela-

rusian and Ukrainian Polessye migrate with a westerly heading along the Baltic coast through Latvia, Lithuania, Poland and eastern Germany, then along the North Sea coast of western Germany, Netherlands, Belgium and sometimes England, thereafter heading south along the French and Iberian Atlantic coast as well as along the Mediterranean coast (SCHULZE-HAGEN 1993).

Scattered records are known from the Mediterranean (as prey in nests of Eleonora's Falcon), Jordania and N-Turkey (K. GUTTERIDGE, unpublished report), perhaps indicating the existence of another, much less frequented flyway along the Black and Mediterranean Seas. There is no evidence for different migration routes during spring and autumn migration, although DE BY (1980) stated: "In spring the Aquatic Warbler is a rare bird throughout western Europe, especially in the west and north and seems to prefer a more easterly route than during autumn migration. This is indicated by only two records for the British Isles, rarity in Western France and relative abundance in Switzerland at the Bodensee and in Germany. MESTER (1967) suggested a more direct return to the breeding areas when discussing German records". In Spain for instance, the species occurs during both migration seasons, in spring also singing and partially moulting birds have been regularly observed (e.g. Moro Marshes, M. Y. BLASCO, pers. comm.).

The winter quarters are located in West Africa south of the Sahara. They include wetlands and floodplains of Mauritania, Mali, Ghana and Senegal, but little more is known about the species during winter.

Table 1: Population of the Aquatic Warbler in Europe. Figures for Germany, Hungary, Poland, Lithuania, Belarus and Ukraine are from recent surveys (1996-1998); the remainder are rough estimates (shown in brackets). Trends are estimated from earlier surveys or habitat area balance of the last 20-30 years (where earlier surveys are lacking). – *Brutbestand des Seggenrohrsängers in Europa. Die Zahlen für Deutschland, Ungarn, Polen, Litauen, Belarus und Ukraine stammen von aktuellen Bestandsaufnahmen (1996-1998); die übrigen Werte sind grobe Schätzungen (in Klammern). Der Populationstrend wurde abgeleitet durch den Vergleich mit früheren Schätzwerten oder anhand von Flächenbilanzen von potentiellen Brutbabitaten (Seggenmooren) in den letzten 20-30 Jahren.*

Country	No. of singing ♂ (surveys 1996 - 1998)	current trend	estimate in TUCKER & HEATH (1994)
Belarus	7,300 - 13,000	–	0
Germany	40 - 50	(–)	30 - 100
Hungary	c. 600	++	150 - 200
Latvia	0		(10 - 50)
Lithuania	250 - 400	?	(50 - 200)
Poland	2,900 - 3,000	–	2,500 - 7,500
European Russia	(10 - 500)	?	(1,000 - 10,000)
Ukraine	2,400 - 3,400	–	1 - 10
Total	13,500 - 21,000	–	3,700 - 18,000

3.3. Major threats and limiting factors

The major threat factors which have been identified at the known breeding sites are briefly summarised below. More detailed information for Poland and the Polessye is given by KOZULIN & FLADE (1999) and KLOSKOWSKI & KROGULEC (1999) in this issue.

- **Loss of breeding habitat** is usually related to drainage for agriculture or peat extraction/excavation, daming of floodplains (Pripyat, Yaselda), unfavourable water management (e.g. water extraction or drainage of adjacent areas) and canalisation of rivers. Currently there are problems at several sites in Poland, Belarus and Ukraine with drainage amelioration and peat extraction affecting adjacent sedge fens (upper Pripyat, Zvanets, Dikoe, Sporova) and also still direct destruction of fen mires in Ukraine (Volyn and Rivne regions) and Belarus (e.g. S of lake Sporovskoe).

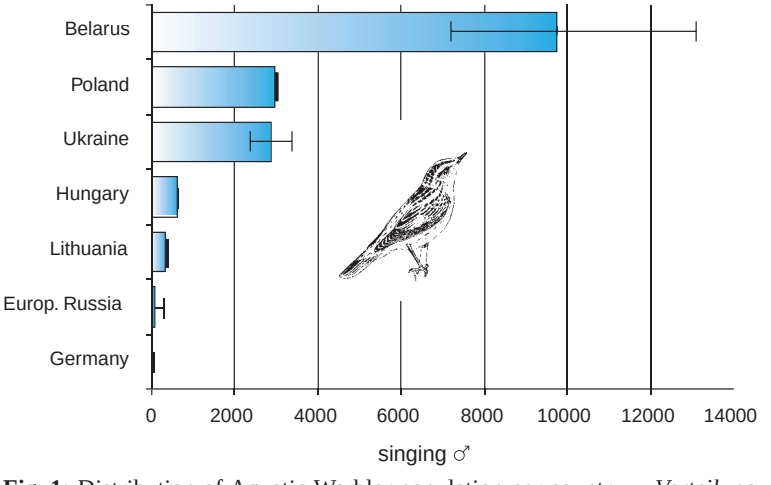

Fig. 1: Distribution of Aquatic Warbler population per country. – *Verteilung des Seggenrohrsänger-Weltbestandes auf Staaten.*

Fig. 2: World breeding distribution of Aquatic Warbler. – *Gesamtbrutverbreitung des Seggenrohrsängers.*

- **Habitat changes** related to vegetation succession is an important factor in Poland (Biebrza and Lublin marshes), Lithuania (Zuvintas), Russia (Kaliningrad region), Belarus (Zvanets, Sporova), and Ukraine (huge areas in the upper Pripyat region), where, if cutting of vegetation and/or burning (or at some places grazing) is abandoned, natural succession sets in and the habitat becomes unsuitable for Aquatic Warblers due to overgrowing by high reeds, willows *Salix spec.* or successional forests of birch or alder. In the past, reeds used to be occasionally harvested in the Biebrza and Zvanets mires and along Yaselda, Stochid and upper Pripyat rivers for use on floors and for roof thatching etc., together with the more important harvesting of sedges as poor-quality hay and the active elimination of bushes. These traditional activities have now ceased at many places due to socio-economic changes.

- **Uncontrolled burning**. Burning is often used as a management tool in pastoral agriculture. Uncontrolled fires, especially in spring and summer and if the mire is very dry, cause severe habitat destruction by burning the upper peat layer. In the Biebrza marshes there was a 3,000 ha fire in 1986 which caused a great deal of soil mineralisation. However, uncontrolled burning is more often a direct threat to birds and nests during the breeding season. Large spring and summer fires occurred also in the Zvanets an Yaselda mires in Belarus. In Hungary, burned areas of suitable habitat were reoccupied by Aquatic Warblers only 5-6 years after fire. But note that controlled burning in winter or early spring can be an appropriate management measure for maintaining the habitat quality.

- **Eutrophication** from mire drainage. Mineralisation of mires due to lowered water levels leads to minerals being washed downstream toward flooded Aquatic Warbler habitats, thus speeding up the rate of vegetation succession. This could be an important factor (Yaselda incl. Sporova mires, Belarus; several areas in the upper Pripyat region, Ukraine).

- **Flooding** of fen mires during the breeding period. In the Yaselda river valley mires, in some years all Aquatic Warbler nests are lost to summer floods in June or July, which are mainly caused by heavy rainfall (KOZULIN *et al.* 1998, KOZULIN & FLADE 1999).

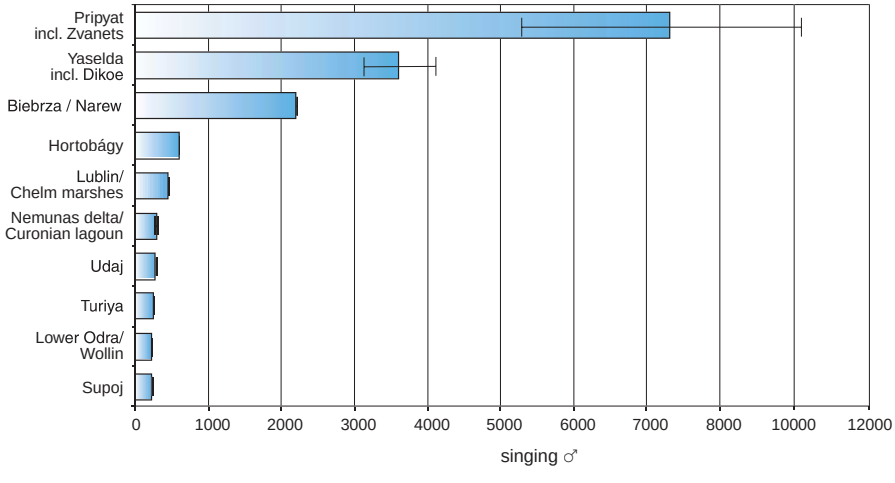

Fig. 3: Distribution of Aquatic Warbler population in the 10 most important river and mire systems. – *Verteilung der Seggenrohrsänger-Weltbestandes auf die zehn wichtigsten Fluß- und Moorsysteme.*

- **Habitat changes in wintering areas**. Drought and habitat alteration in the winter quarters could be true bottlenecks for the Aquatic Warbler. The main threats which have been identified are: drying up due to periods of drought; drainage projects to enable irrigation and farming; increasing human population; overgrazing of grasslands by cattle; succession of grass associations into scrub; increasing desertification as well as salinisation of irrigated soils.

4. Population size, trends and conservation status in single countries

4.1. Belarus

4.1.1. Survey methods, census and monitoring

In the early 1990s, the Aquatic Warbler was thought to be extinct in Belarus (TUCKER & HEATH 1994). To verify this assumption, survey work in Belarus started in 1995, when a joint Belarusian-German expedition (A. KOZULIN and co-workers, M. FLADE and co-workers) investigated the middle Pripyat region. We used a helicopter for survey flights to locate suitable habitat patches from the air and afterwards surveyed those localities on the ground. After finding the first singing Aquatic Warblers near Pinsk, similar habitats known by the Belarusian colleagues in the wider surroundings were visited, but some of them have since been drained (e.g. southern part of Zvanets). However, in 1995 the first Aquatic Warbler populations were found at the lower Yaselda (Yaselda mouth E Pinsk), in the Zvanets mire SW Kobryn and in the Yaselda valley near Chomsk. The first density estimate was obtained from a 20 ha plot in Zvanets.

In 1996 and 1997, systematic surveys were carried out in nearly all possible habitats in entire Belarus, organised by A. KOZULIN (Academy of Sciences Belarus) and funded by the Michael Otto Foundation for Environmental Protection, Germany (co-ordinator M. FLADE). The currently known breeding habitats were identified on a high-quality vegetation map from 1977 (scale 1 : 750,000) and could be associated precisely with two vegetation units, which still covered about 3,800 km² on this map. As the next step, information about drainage and land reclamation activities during the last decades was obtained from the state land reclamation companies and institutes. This information was completed by checking of aerial photos, interviewing of colleagues and local experts and by our own field knowledge. Following this method, potential remaining fen mires and sedge meadows were selected, which were then surveyed in the field.

During fieldwork between mid-May and mid-July (multiple visits up to mid-August), densities of singing ♂ were estimated by using transect counts, starting about 60 minutes before and finishing about 45 minutes after sunset (so called "sunset counts"). The width of transects was 200 m (100 m each to the left and to the right), using representative routes through all habitats of the respective open fen mire. About 1 – 1.5 km² can be surveyed in one evening by three or four observers. Habitat patches of less than 100 ha were surveyed completely. Estimates of the total population of each mire were then possible by combining density values and estimates of habitat area derived from maps and aerial photos.

In the period 1995 - 1997, 16 plots with a total of 1,819 ha were surveyed (sunset-counts), and 803 singing ♂ were mapped (44.1 ♂/km² on average) in the Belarusian and Ukrainian Polessye. Additionally, short visits to potential habitat patches during daytime yielded another 417 singing ♂, which indicated further occupied breeding sites (reliable density values cannot be obtained from daytime counts). A total of 29 breeding sites totalling 61,000 ha of fen mires has been surveyed, and about 10 % of the estimated total population of Aquatic Warbler has been mapped or counted.

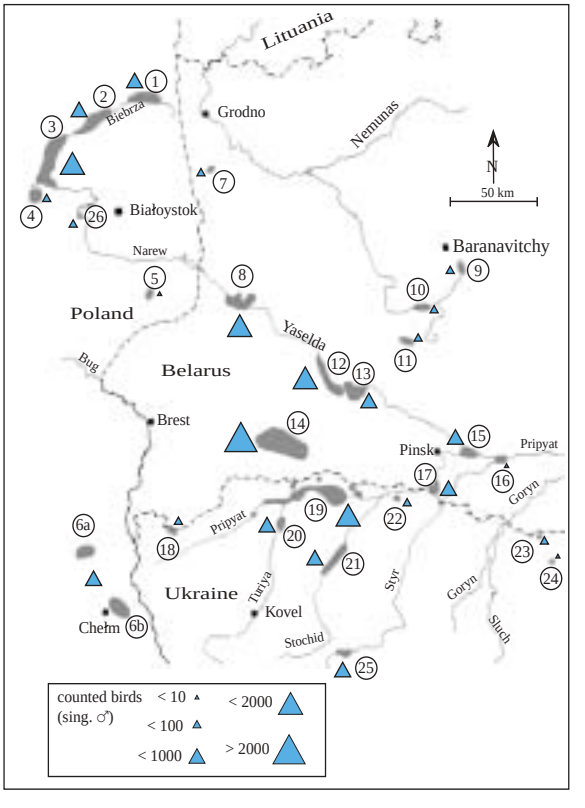

Fig. 4: Detailed map of Aquatic Warbler distribution in the European core area of Polessye and E-Poland (1996-1998). – *Detailkarte der aktuellen Seggenrohrsänger-Verbreitung im europäischen Kerngebiet in der Polessje und Ostpolen (1996-1998).*

In 1998, counts were repeated in the most important mires. Six monitoring plots of 40-120 ha each were established in the five most important fen mires of Belarus for studying changes in Aquatic Warbler density, hydroregime, vegetation composition and structure, food availability and other essential habitat parameters. During May-July 1998 three surveys (May 21-29, June 22-26, July 20-25) of the density of singing ♂ were performed (sunset counts). Further the plots were divided into squares of 100 x 200 m. At the same time species composition of all breeding birds in the mire was determined.

On two of these plots, in the Dikoe mire (80 ha, 1,000 x 800 m) and Yaselda floodplain (68 ha, 1,700 x 400 m), studies on nesting seasonality, breeding success and diet were initiated in 1998 by the Academy of Sciences Belarus (funded by the Royal Society for the Protection of Birds, UK).

4.1.2. Current population size

The surveys in 1995-1998 showed that Belarus holds more than half of the known world population of Aquatic Warbler: a total of 7,300 - 13,000 singing ♂ distributed over 12 breeding sites (table 2). The most important remaining breeding site is the Zvanets mire (190 km^2) near Kobryn (no. 14 in fig. 4), Brest region, with 3,600 - 7,600 singing ♂ (yearly changes depending on water table fluctuations). Other important mires are Dikoe (Yaselda and Narew spring, Brest region, 81 km^2; no. 8 in fig. 4) with c. 1,700 - 1,800 singing ♂ and the mires along the Yaselda river between Berioza and Sporova lake (50 km^2, c. 1,360 - 2,100 singing ♂; no. 12 and 13 in fig. 4).

4.1.3. Trends and threats

From a retrospective balance of open fen mire areas since the 1960s, it can be estimated that suitable habitat area and population size of Aquatic Warbler must have suffered a decline of more than 90 % within the past 30 years, mainly due to drainage, land reclamation and peat extraction (KOZULIN & FLADE 1999). Almost 15,000 km^2 of fen mires have been drained since 1960; the open fen mire area decreased from c. 3,800 km^2 to c. 440 km^2. Out of the remaining 440 km^2, c. 154 km^2 (15,400 ha) are thought to be still suitable for Aquatic Warbler (open sedge fen of medium vegetation height with shallow water or water-saturated ground cover of green mosses).

Apart from the effects of direct destruction, formerly a much higher proportion of fen mires must have been suitable for the species due to traditional use by cutting and burning. An increasing percentage of remaining fen mires is no longer suitable to the species because of abandoned land-use, followed by overgrowing with reeds, bushes and successional forests.

The threats to and current situation of the fen mires of Belarus are described in detail by KOZULIN & FLADE (1999, this issue). It must be emphasized that despite of comprehensive conservation measures (see 4.1.4.), the decline of Aquatic Warbler in its core breeding area is still continuing due to ongoing abandonment of land, vegetation succession and also local drainage and land reclamation of smaller areas.

Table 2: Results of the Aquatic Warbler survey in Belarus, 1996-1998. Density values are derived from sunset counts on study plots (compare text). Minimum and maximum densities show variations between different subareas and/or different years (see 4.1.1. and KOZULIN & FLADE 1999); values marked with * indicate total numbers of counted birds (not densities). – *Ergebnisse der Seggenrohrsänger-Bestandserfassung in Belarus 1996-1998; die Dichtewerte wurden mittels Zählungen während des Sonnenuntergangs auf Probeflächen ermittelt, die Schwankungsbreite beschreibt Unterschiede zwischen verschiedenen Teilflächen und/oder verschiedenen Jahren (s. 4.1.1. und KOZULIN & FLADE 1999); mit * markierte Werte betreffen Absolutzahlen, keine Dichtewerte.*

site (numbers compare fig. 4)	total open fen mire area (km2)	suitable habitat area (km2)	density, ♂/km^2 (plots)	population estimate
Dikoe (8)	81	24	50 - 62	1,700 - 1,800
Yaselda S Berioza (12)	25	16.5	25 - 135	940 - 1,550
Yaselda - Sporova (13)	24	10	30 - 40	420 - 570
Zvanets (14)	190	80	45 - 95	3,600 - 7,600
Lower Yaselda (15)	20	7	10	120 - 160
Lower Prostyr (17)	30	10	23	450 - 900
Lower Styr (16)	24	5	5*	10 - 100
Svisloch S Grodno (7)	20	0.3	4*	10 - 50
Bobrovichskoe Lake (11)	10	0.1	1*	10 - 50
Shchara - 4 (10)	10	0.5	2*	10 - 100
Shchara - 2 (9)	5	0.2	5*	10 - 50
Braginka	5	0.3	2*	10 - 100
Total	444	154	25 - 135	7,290 - 13,030

4.1.4. Conservation status

The Aquatic Warbler is classified as endangered in the Red Data Book of Belarus and is legally protected. Protection of the species is a goal of the "National Strategy and Action Plan for the Conservation and Sustainable Use of Biological Diversity in the Republic of Belarus", which has been ratified by the government of Belarus in 1997.

About two third of Zvanets are nature reserve (zakaznik), the rest is unpro-

Table 3: Results of the Aquatic Warbler census in Poland (1995-)1997, and comparison with survey data from previous years. Figures refer to the number of singing males. – *Ergebnisse der Seggenrohrsänger-Bestandsaufnahme in Polen (1995-)1997 und Vergleich mit Ergebnissen früherer Zählungen. Angegeben ist die Anzahl singender Männchen.*

Region (from NW to SE) (numbers compare fig. 4)	current population estimate	year of census	data from previous years		trend
Western Pomerania (lower Odra, Wollin, Kasiborski Kępa etc.)	226 - 231	1997	1991: 383	1993: 217	(–)
Slonsk reserve (lower Wartha)	21 - 23	1997			
Ner river mouth near Dąbie	2 - 3	1996			
Kleszczynek lake	0	1997	1991: 4		–
Mazury, Nietlickie Marshes	5	1997	1990: 10	1994: 3 - 4	(–)
Szkwa and Omulew valleys	0	1997	1995: 7 - 10		–
Biebrza marshes	**2,041 - 2,082**	**1995-97**	1991: 2,500 - 3,500		–
Northern Basin (1)	161	1997			
Central Basin (2)	302 - 312	1997			
Southern Basin (3)	1,578 - 1,609	1995			–
Lower Narew	1	1997	1990: 35	1994: 15	–
Wizna marshes (middle Narew) (4)	79	1997	1989: 40 - 44	1995: 50-52	+
Upper Narew (26)	54 - 70	1997	1988: 118 - 133		–
Hajnówka region (5)	2	1997	1987: 7		(–)
Kampinoski National Park	3	1996			
Lublin region, Chelm marshes (6)	451	1997	1993: 308		+
total	**2,885 - 2950**	1995-97	1989-95: **3,200 - 4,450**		**–**

tected (western part) or has been drained for agriculture during the past 10 years (southern part, drainage work was still going on in 1995/96). Most of the Dikoe mire has been declared a hydrological reserve (zakaznik), but negative impact from drained land in the eastern part is continuing. It is planned to include the whole Dikoe mire into the adjacent Belaveshkaya Pushcha National Park. The Yaselda mires S of Berioza are unprotected, but the establishment of a large reserve (zakaznik) of 190 km^2 between Berioza and Sporova lake is in preparation and will probably take effect in 1999. The Sporova mires are largely included in the existing Sporovskoe zakaznik, but are threatened by drainage of adjacent areas and input of mineral and fertiliser load into Sporova lake from drained lands in the surroundings. Other mires with smaller Aquatic Warbler populations (e.g. Yaselda mouth E Pinsk, Prostyr and Shchara floodplain mires) are mostly protected as zakazniks.

4.2. Poland

4.2.1. Survey and census methods

The knowledge about numbers and distribution of Aquatic Warbler in Poland in the early 1990s was first summarised by DYRCZ & CZERASZKIEWICZ (1993). This report revealed that only in Western Pomerania was there any figure for the total population of the region. For most of its range in Poland, especially the large Biebrza and Narew valleys and Lublin area, only estimates made by extrapolating from densities on sample plots to the whole suitable area existed. But the authors proposed a counting method which made it possible to conduct censuses of large areas with minimal estimation error. This method was applied in the first country-wide survey in 1993. This census did not include the major breeding site, the Biebrza marshes, where a complete census was performed in the southern basin in 1995.

In 1997, the first country-wide survey was performed within a single year (KROGULEC & KLOSKOWSKI 1998, unpublished report). The census was carried out during the period of peak ♂ activity between 20 May and 14 June 1997 throughout Poland, with the exception of the northern Biebrza basin, where only a few representative areas were surveyed. In the southern Biebrza basin, which had already been surveyed in 1995, only some repeat counts were made in four selected subareas. In the national survey, all probable breeding sites were divided into subareas of about 200 - 300 ha, which could be counted by groups of 4-5 observers within 2 hours around sunset. During each count, the individual members of the team were arranged in an extended line within sight and hearing of one another (distances varied according to the degree of scrub coverage between 50 - 100 m). Each team member counted the ♂ singing on the strip between himself and one of his neighbours (either left or right). The number of singing ♂ recorded within the strips were added up for the whole area. In total, 61 observers participated in the survey of the Biebrza marshes. The survey of the other Polish breeding sites was performed by local or regional observer groups under the supervision of 6 regional co-ordinators. Habitat descriptions were also obtained during each survey (data analysis see KLOSKOWSKI & KROGULEC 1999, this issue).

4.2.2. Current population size, trends and conservation status

The Aquatic Warbler is protected under the Nature Conservation Law of 1991 and is listed in the Polish Red Data Book as 'endangered' (GLOWACINSKI 1992). Table 3 shows current population estimates and trends in Poland. The total population has suffered a distinct decline during the past 10 years. Details on threats and conservation measures needed are presented by KLOSKOWSKI & KROGULEC (1999, this issue). There are three main subpopulations:

1. **Biebrza** (no. 1-3 in fig. 4) is the most important breeding area, with 2,041 - 2082 singing ♂ in 1997. A continuing population decline due to overgrowing by reeds and willow-birch communities is ultimately caused by lowering of the water table and cessation of cutting and grazing. Although a National Park has been established in 1993, this crucial conservation problem has not been solved yet.
2. **Chelm** (no. 6 in fig. 4) is part of the Lublin marshes, and the Aquatic Warbler is present in four neighbouring blocks totalling 15 km². In 1997, 451 singing ♂ were counted; the highest density was 4-6 ♂/ha. The population has increased during the 1990s. Current threats again include lowering of the water table and accelerated vegetation succession at some sites, and also uncontrolled burning during or just prior to the breeding saison. A management plan has been produced by OTOP. Two specific management actions have been implemented: cutting of scrub to create more open habitat and promote colonisation by Aquatic Warbler (by OTOP); and cutting of trees to clear the habitat (by the Lublin Forest Authority).
3. In **Western Pomerania** (lower Odra and Odra estuary) the number of singing ♂ recorded in 1997 was 226 - 231. Although there may be some sites still unknown, the population is probably decreasing. There are 10 sites holding Aquatic Warblers which are at present unprotected. Nearby is Wolinski National Park which could be extended to cover two islands of the Swina river mouth. A Landscape Park has been established in the Inter-Odra region, the first step for a future cross-border National Park with Germany in the south of Szczecin. OTOP has established a private reserve in the island of Karsiborska Kępa. Threats result mainly from abandonment of hay meadows, advancing succession of reeds and over-exploitation of reeds.

4.3. Ukraine

4.3.1. Surveys and census methods

Since the last breeding records in Ukraine in 1979 and 1980 (Zhitomir region, Ovruch district, HLEBESHKO 1992), the first recent populations of Aquatic Warbler were discovered by I. GORBAN and V. MATAYCHIK in the Shatsk National Park in 1993 and A. POLUDA and G. GAWRIS in the Supoj valley E Kiev in 1995. Systematic surveys started in 1996, when a joint Belarusian/German kayak expedition was conducted along the upper Pripyat between Ratno and the border of Belarus (M. FLADE, J. JEBRAM, T. LEINWEBER, A. TISHECHKIN), and a Ukrainian/German expedition went to Supoj marshes (M. FLADE, G. GAWRIS, J. JEBRAM, T. LEINWEBER, A. POLUDA). In 1996 the upper Pripyat population was discovered and the Supoj population was censused by sunset counts.

In 1997, a systematic survey by A. POLUDA and co-workers (funded by Vogelbescherming Nederland) covered the northeastern part of Rivne region, northern part of Zhitomir region, large parts of Kiev and Chernigiv regions (e.g. Supoj and Udaj valleys) and the marshes of Orzhitsa and Sula rivers in Poltava region (POLUDA 1997, unpublished report). In the same year, another international expedition (funded by Otto Foundation) with participants from Ukraine (I. GORBAN, V. MYTAYCHYK), Belarus (A. KOZULIN and co-workers) and Germany (M. FLADE and co-workers) went again to the upper Pripyat region and checked the mires more distant from the river (especially along the border to Belarus), which had been omitted in the previous year, the Shatsk National Park and the middle and lower courses of Turiya and Stochid rivers. In this year, the Udaj, Turiya and Stochid populations were discovered.

In 1998, A. POLUDA and co-workers investigated practically all remaining "natural" sedge marshes in Vinnitsa, Ternopil, Khmelnitsky, Chernigiv, Zhitomir, Kyiv, Poltava and Rivne regions, but except for some small groups of 3-12 birds only two larger populations (150 - 200 singing ♂ each) were found in the middle Styr valley and along the lower Cyr. Most of the investigated mires had been drained in the years before. It thus seems unlikely that any other large populations will be found in central and western Ukraine in the future.

The field methods used in Ukraine were the same as in Belarus: total counts or transect counts within a 200 m strip around sunset, other sites were checked during daytime without estimation of densities (method see 4.1.1., details for Ukraine see Table 4).

4.3.2. Population size and distribution

The surveys in 1996-1998 revealed a total Ukrainian population of 2,400 - 3,400 singing ♂. About 80 % of the national population is concentrated in the Northwest (Volyn and Rivne regions) along the upper Pripyat and its tributaries (Turiya, Stochid, Styr) and surrounding mires. The upper Pripyat population is directly adjacent to the Polish Lublin/Chelm population further west and the major Belarusian population of Zvanets to the north. In contrast, the Udaj and Supoj populations (450 - 550 ♂ in total) are more or

less isolated in north-central Ukraine, E and NE of Kiev. Some scattered small groups of singing ♂ in the northern Chernigiv region and in the Belarusian part of the Chernobyl zone can also be included into this central Ukrainian subpopulation, which seems to be the easternmost self-sustaining, viable population in Europe.

4.3.3. Threats and conservation status

Although reliable data are lacking, we must assume that the Aquatic Warbler suffered a dramatic decline in all of Ukraine due to habitat loss during the past decades. Nevertheless, the current situation of the two sub-populations seems to be very different. Although Aquatic Warblers must have been far more widespread in central Ukraine in former times and immense habitat losses due to drainage and land reclamation occurred until recently (as shown by surveys in e.g. Zhitomir, Chernigiv, Vinnitsa, Khmelnitsky and Poltava regions), the Udaj and Supoj populations seem not to be threatened at present. Major parts are included in protected areas and, more importantly, habitat conditions seem to be rather stable without management. The habitat is a mesotrophic fen mire, which oscilla-

Table 4: Results of Aquatic Warbler surveys in Ukraine 1995 – 1998. Population and density figures refer to the number of singing ♂. – *Ergebnisse der Seggenrohrsänger-Bestandsaufnahme in der Ukraine 1995-1998; Bestandsschätzungen und Dichtewerte beziehen sich auf die Anzahl singenden ♂.*

Region and site name (from NW to SE, numbers compare fig.4)	suitable habitat, ha	survey years	counted males	♂ per km² (sunset counts)	estimated total pop.
Shatsk National Park: Balota Unitchy (18)	**c. 100**	**1997**	**25**	**25.0**	**25**
Upper Pripyat marshes/adjacent mires (19)	**4200-5000**	**1996-98**	**652**	**15.9-64.1**	**1,325-1,795**
Pripyat Komarova - Prawodki	50	1996	7		25
marshes Retchica - Shchedrogir	450	1996/97	12+13		180-220
Shchedrogir - Turiya mouth	50-200	1996	2		15-90
Kanal Wishewskie - Pripyat	350	1996	14		105-160
Balota Salessye Turiya - Nevir	> 600	1996/97	32+15	15.9-41.4	200-300
Ur. Torople Wjotly - Cyr mouth	c. 2000	1996/98	66+250	16.7-64.1	500-600
Lower Cyr (right bank E Borki)	c. 400 (?)	1998	200		200
Pripyat marsh N Lyubyaz	40-100	1997	2		20-50
W and E Ozero Wolyenskoe	60-200	1997	10		20-50
Ur. Yamki, N Oz. Rosotchkoye	30-50	1997	25-27		30-40
mire SW Getchishcha	>100	1997	5		20-50
between Mlyn and lake Nobel	?	1998	10		10
Lower Turiya: Balota Wishery (20)	**330**	**1997**	**150**	**98.4**	**250**
Stochid valley between Belika Obsyr and Staric Cherwishcha (21)	**(30 km of river valley)**	**1997**	**18**	**2.5-5 ♂ per river-km**	**70-150**
Middle Styr valley near Chetvertnya (25)	**>300 (?)**	**1998**	**150**		**150**
L'va river - SW Almany bog	**>100**	**1997**	**11**		**23-110**
fishponds near Perebrody (23)	100	1997	8		15-100
marshes near Stare Selo (24)	?	1997	3		8-10
Zamglay, Repky distr. (Chernigiv reg.)	**?**	**1998**	**10**		**10**
Snov river SE Petrivka (Chernigiv reg.)	**?**	**1998**	**12**		**12**
Snov valley NE Elino (Chernigiv reg.)	**?**	**1998**	**3**		**3-5**
Udaj valley (NE Kyiv)	**?**	**1997**	**112-114**		**260-300**
Galka river near Bogdanivka		1997	3		3-?
Doroginka - Monastirishche		1997	106		≥250
S of Monastirishche	?	1997	3-5		3-5
Supoj valley (E Kyiv)	**2000-4000**	**1995-97**	**104**	**7.0-77.5**	**220-250**
state reserve Svidovetsky		1997	10		
marshes 3 km S Novy Bykov		1995	10		
S of Stari Bykov		1996	7	7.0	
near Mala Berezanka		1996	36	36.0	
near Ozhurnoye		1996	10	25.0	
near Supojowka		1996	31	77.5	
further unknown breeding sites					**50-150**
total	**8,000-12,000**	**1996-98**	**c. 1,243**		**2,400-3,400**

Fig. 5: Aquatic Warbler on the ground of sedge thicket (Photo: Andrzej BALINSKI). – *Seggenrohrsänger am Grunde des Seggendickichts.*

Fig. 7: The Aquatic Warbler habitats along the upper Ukrainian Pripyat are nearly completely maintained by hand cutting of the sedge meadows for hay making; downstream Retchica, May 1996 (Photo: M. FLADE). – *Die Seggenrohrsänger-Habitate entlang des oberen ukrainischen Pripjets sind nahezu vollständig von der Heunutzung durch Handmahd abhängig; unterhalb Retschitsa, Mai 1996.*

Fig. 6: The valley of the upper Ukrainian Pripyat is characterised by wide floodplain mires comprised of large reedbeds and sedge fens. Pripyat downstream of Shchedrogir, May 1996 (Photo: M. FLADE). – *Die Niederung des oberen Pripjet in der Ukraine ist durch weite Talmoore mit ausgedehnten Schilfröhrichten und Seggenrieden gekennzeichnet. Pripjet unterhalb Schtschedrogir, Mai 1996.*

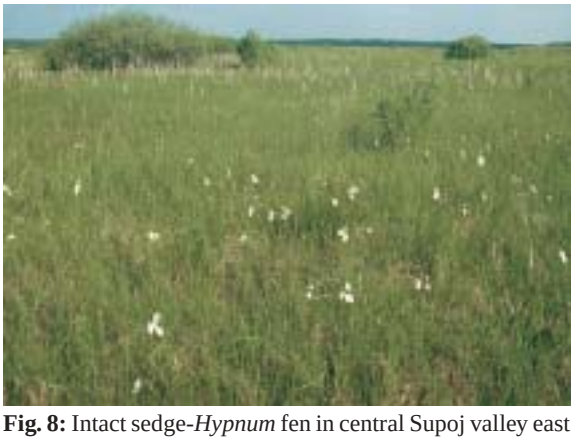

Fig. 8: Intact sedge-*Hypnum* fen in central Supoj valley east of Kiev, where Aquatic Warbler occurs at high density. This primeval habitat is not used for agriculture and also not burned by local people (Photo: M. FLADE, late May 1996). – *Intaktes Braunmoos-Seggenmoor am mittleren Supoj östlich Kiev mit hoher Seggenrohrsänger-Dichte; dieser natürliche Lebensraum ist weder landwirtschaftlich genutzt noch durch Abbrennen gepflegt.*

Fig. 9: Large sedge-fen mire along the Pra River west of Spas-Klepiki, Ryazan district, central European Russia. Despite some older records, Aquatic Warbler was not found here in 1998, possibly due to the high spring floods in that year (Photo: M. FLADE, late May 1998). – *Ausgedehntes Seggenmoor am Fluß Pra westlich Spas-Klepiki, Bezirk Ryasan, Zentralrussland. Trotz einiger älterer Nachweise konnten hier 1998 keine Seggenrohrsänger gefunden werden, möglicherweise wegen des ungewöhnlich hohen Frühjahrshochwassers (Ende Mai 1998).*

tes according to the river water table and is not regularly used for cutting or grazing. There were also no signs of impact of burning in the survey years. In the past, Aquatic Warbler habitat in Supoj valley has been destroyed by damming of fishponds and alteration of water table, and large parts of Udaj valley have formerly been drained. Thus the remaining breeding habitats are remnants of a much larger suitable area. Protection of the remaining habitat in its current condition should be ensured by legislative and administrative measures.

In contrast, the upper Pripyat population obviously is declining sharply. On the one hand, drainage for agriculture and peat excavation has destroyed huge fen mire areas even during the past 5 - 10 years (e.g. between Ratno and the Belarusian border or between Pripyat and Prostyr) and is still continuing (e.g. mires E of Stochid valley); the amount of direct habitat loss is difficult to assess, but is likely to have exceeded 80 % within 30 years. On the other hand, the remaining fen mires are heavily impacted by vegetation succession (overgrowing with willow bushes, alder and birch) due to alterations of the water regime and cessation of traditional land-use practices (hand scything, winter burning, low-intensity grazing). The most suitable and stable (but also declining) habitats have survived very close to the Pripyat river, where regular flooding and high water table constrain vegetation succession (e.g. downstream of Retchica and around Shchedrogir) and in some areas, where hay making still takes place (e.g. lower Turiya, Balota Wishery).

The two most important subsites, Balota Salessye (200-300 ♂) and the Pripyat marshes between Wjotly, Borki and Cyr mouth (500-600 ♂), are still used for hay making in some parts (mostly smaller patches), but more than half of these floodplain mires was overgrown by willow shrubs in the meantime. Without large-scale habitat management Aquatic Warbler populations at these sites are likely to become extinct within the next 20 - 30 years.

The situation of some remaining mires north of the Pripyat more distant to the river is even worse (Ur. Yamki N Oz. Rosotchkoye, Gretchishcha). Since agricultural use has mostly been abandoned and drainage of adjacent areas affects those mires, the last singing Aquatic Warblers are concentrated in some smaller remaining open patches which will be overgrown by bushes and trees within the next 5 - 10 years.

The Aquatic Warbler habitats along the Stochid valley are rather atypical. The whole valley has a mosaic structure with hay meadows, reeds, small water courses, willow thickets, more dry pastures and shallow depressions with sedge marshes. Suitable habitat forms scattered patches along the whole valley, mostly along the outer edges. Aquatic Warbler density is very low. For protecting this area as a breeding site, the current way of traditional farming has to be maintained.

Parts of the Aquatic Warbler habitats in the upper Pripyat region are included in protected areas: Balota Unitchy belongs to the Shatsk National Park; 20 % of Ur. Torople between Wjotly and Borki, 50-60 % of Stochid valley and the area N Lyubyaz are zakazniks. It is planned to include all important sites into "zakazniks of national importance" in the near future. These conservation measures are welcome, but not sufficient without implementation a of well-founded management plan, which is urgently needed. The Aquatic Warbler will be included in the new edition of the Red Data Book which is now being prepared.

4.4. Russia

The Aquatic Warbler is rare and of erratic occurrence at least in the European part of Russia. A review of all available literature in Russia (see below) shows that the species was very rare in all of European Russia during the past 100 years. Only little information is available on breeding (occasional or non-permanent). Currently, no stable local breeding population is known, and none were known in Russia in the past at all. Moreover, the trend in the number of records is negative. There is little hope for any large unknown breeding populations of Aquatic Warbler to be discovered in the European part of Russia.

Recently, new information was received about some scattered, irregular and small breeding populations in the South Ural region (area of Kama reservoir and Kama river/Perm region, Bashkiria, Chelyabinsk and Sverdlowsk regions; KARYAKIN 1997, unpublished) and one presumable "breeding pair" was discovered in 1993 (AS'KEEV & AS'KEEV 1994). Furthermore, RAVKIN *et al.* (1997) believe that there still exists a larger breeding population of several thousand birds in W-Siberia (see below).

In general the habitats of Aquatic Warbler described from Russia include lightly flooded grassland, mainly sedge, fen mires in river valleys or other lowlands characterized by continuous influx of water. All breeding and summer records in Russia are confined to a latitudinal belt where fen mires are the pre-dominating mire type (according to BOCH & MAZING 1979, see fig. 10). RAVKIN (1973) specifically notes that the area inhabited by a large Aquatic Warbler population in the Tomsk Region in 1967 was a large fen mire. Records of small groups of singing ♂ in the Ural region are also connected with areas of sedge mires (KARYAKIN 1997, unpublished). Detailed habitat descriptions of the species are very scanty in the Russian literature. These are insufficient to gain a clear picture about the occurrence of habitat features of primary importance to Aquatic

Warblers: water level and its dynamic, structure of vegetation including height of grass and tussocks, composition of plant species, percentage of territory covered by bushes, degree of eutrophication etc.

To determine the true breeding range we can use only a few references containing data about nests or fledglings (see below and fig. 10). Finally, no nest or nestling is preserved in any of the major Russian zoological collections, and only one fledgling is present in the Zoological Museum of Moscow University (a young ♀ from a brood, Moscow Region, 19 July 1911).

4.4.1. European Russia

In the 1990s, a small population (not more than 4 singing ♂) was found at the Curonian Lagoon in Kaliningrad region in close neighbourhood to the Lithuanian core population (KALYAKIN 1996). Special efforts to find breeding birds in the other parts of European Russia were made 1993-1995 and particularly in 1998, when the most promising sites in the Perm region and Meshchera mires in Ryazan, Moscow and Vladimir regions were visited by a German-Russian team (FLADE, KALYAKIN, BAUMUNG). These searches were unsuccessful, even though some suitable habitat was found, especially along the Pra river W Spas-Klepiki, Ryazan region. This should be surveyed further in the future (c. 800 ha open sedge fen mire).

Based on the lack of concrete breeding evidence, FLADE & KALYAKIN (unpublished report, 1998) proposed that all records in European Russia relate to birds of a remaining isolated breeding population in western Siberia, which passes through European Russia along a narrow, latitudinal corridor. Birds may sometimes stop over and occasionally breed at suitable places (see fig. 10). Further study is urgently needed to clarify the situation.

A shortened version of the comprehensive documentation from KALYAKIN (1998, unpublished) on the occurrence of the species in European Russia is presented below, taking into consideration only potential breeding birds. The publication of this documentation appears worthwhile because of persistent speculations about the occurrence of a large permanent breeding population in European Russia.

1. **Kaliningrad Region**: Individual ♂ were found in the delta of the Neman River on the border to Lithuania in the 1930s. Several ♂ were seen near Misovka village, Slavsk District (55°N, 21° 30'E) in 1936; ♂ on the east and southeast coast of the Courish Gulf in 1910-1930s and 1990s (three records), birds on the Baltic Sea coast in the West of the region in the 1920s (TISCHLER 1941; G. GRISHANOV, pers. comm.). Four singing ♂ were found by G. GRISHANOV on 8 June (three birds) and 14 June (one bird) on the southeastern shore of the Courish Gulf near Polessk (54°53'N, 21°07'E; KALYAKIN 1996).
2. **Tver Region**: One ♂ was obtained on the small Losnica River, a tributary of the Mologa River (58°N, 35°50'E) on 9 June 1910 (ZINOV'EV 1990 based on TYULIN 1914). Two records were obtained 50-70 km further west of this point on 20 May 1977 and 28 May 1978 near Verestovo Lake, along the upper Mologa and Osen' Rivers (ZINOV'EV 1990).
3. **Ivanovo Region**: Aquatic Warbler was mentioned as a breeding bird of the region without details by ZINOV'EV (1990). This is presumably a result of changes in the regional boundaries, which now include Plescheevo Lake in the Yaroslavl' Region.
4. **Moscow Region**: Only one old breeding record exists from west of Moscow in Noginsk District, near the Kupavna railway station (55°50'N, 38°30'E): two young were collected from a group of three birds on an overgrowing peat moorland on 6 July 1912 (POLYAKOV 1912). This author was

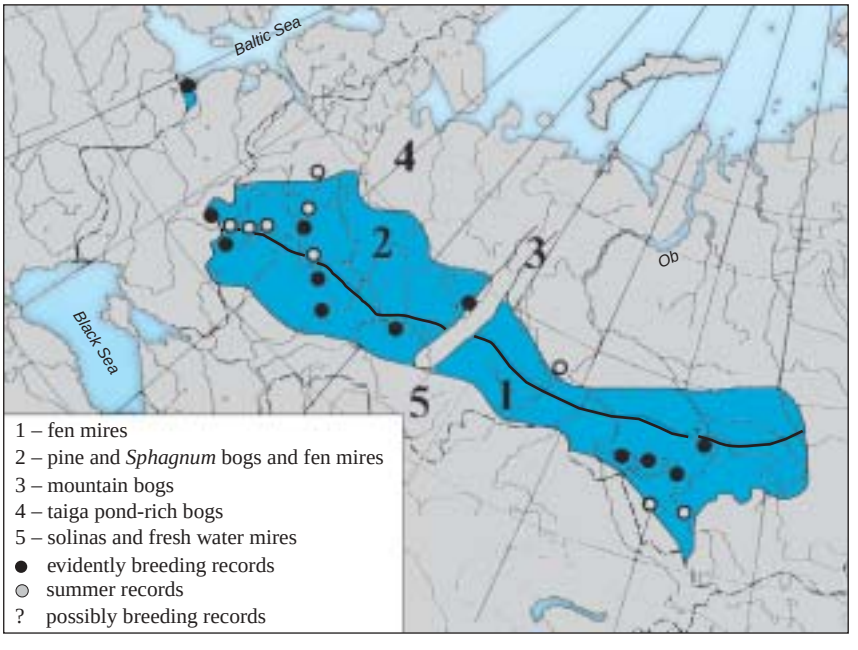

Fig. 10: Breeding and summer records of Aquatic Warbler in Russia during the 20th century within different mire types (from KALYAKIN 1998, unpublished report). – *Brut- und Sommernachweise des Seggenrohrsängers in Rußland im 20. Jahrhundert in Beziehung zur Verbreitung verschiedener Moortypen.*

sure that the Aquatic Warbler breeds in the area (POLYAKOV 1916, 1924). Later only two more records came to light: one actively singing ♂ was observed west of Moscow in Vinogradovo floodplain (55°27'N, 38°30'E), Voskresensk District, on 14 May 1983 by V. ZUBAKIN, but was not found here several days later (ZUBAKIN *et al.* 1988); one "pair" including an actively singing ♂ was discovered north of Moscow in the Dubna River valley (56°35'N, 38°05'E), Taldom District, on 26 June 1980 (GARUSHANTS *et al.* 1990). Also some very doubtful records over the last decade from the northwestern part of the region, Lotoshino District (c. 56°15'N, 35°50'E; D. KONSTANTINOV 1995, pers. comm.; V. FRIDMAN 1995, pers. comm.; BORODIN & KOROL'KOV 1998.).

5. **Kaluga Region**: The only data for this region are by GENGLER & KAWELIN (1903) who mentioned that Aquatic Warbler bred in the Zhizdra River valley, Kozelsk District, at the end of 19th century (c. 54°N, 34°45'E; FILATOV 1915). Later observers did not find the species in this region.

6. **Ryazan Region**: The species was recorded in Oksky Reserve (54°40'N, 40°40'E) in the Pra River valley on 15 August 1946 and 28 July 1954 (PTUSHENKO 1962; PTUSHENKO & INOZEMTSEV 1968). These authors noted with reference to E. BEKSHTREM (1927) that Aquatic Warbler breeds in South Meshchera. But BEKSHTREM only reported the species' presence near Spas-Klepiki (55°10'N, 40°15'E) without any indication of nesting. At this site, suitable habitat c. 800 ha in extent was still present in 1998, but was flooded up to late May due to exceptionally high spring water levels. Although the species was not found, this place should be surveyed in future (BAUMUNG, FLADE, KALYAKIN).

7. **Bryansk Region**: Aquatic Warbler was recorded breeding in the basin of the middle Desna River south of the border between Russia and Ukraine in 1971 and 1976 (AFANAS'EV *et al.* 1992). One bird was observed on the Desna River valley near Trubchevsk (52°30'N, 33°45'E) on 13 June 1973 (AFANAS'EV 1998). A small breeding population was found in 1941 by M. VOINSTVENSKY (1950) at the Snov River (c. 52°05'N, 33°10'E), presumably on the Ukrainian side of the border.

8. **Orel Region**: Two old records are known here: one ♂ was collected in Orel District (c. 53°N, 36°E) on 25 April 1906 (EFIMOV 1907), and one bird was observed near Ivanovskoe village, Maloarkhangelsk District (c. 52°25'N, 36°30'E) on 28 July 1905 (OGNEV 1908).

9. **Kursk Region**: Breeding record: one ♂ was collected and a brood of fledglings was seen in the vicinity of Dmitrov-L'govskii (52°N, 35°E), not far from the border of Bryansk Region, on 15 July 1927 (PTUSHENKO & INOZEMTSEV 1968).

10. **Mordovia**: A brood of three young was recorded in Mordovian Reserve (54°50'N, 43°20'E) on 4 September 1936 (PTUSHENKO 1938).

11. **Penza Region**: One specimen was collected in Nizhnii Lomov District (c. 53°50'N, 43°40'E), north-west of Penza, on 21 May 1906 (Zoological Museum of Moscow University). Breeding has been recorded in the region by KUZNETSOV (1967): three nests with clutches were discovered in Penza (53°15'N, 45°E) on 18 June 1934 (5 eggs), in the vicinity of Penza on 10 June 1932 (6 eggs), and on 29 June 1959 (4 eggs). Identification remains doubtful, because two of these nests were found "in a big garden" and "on the forest edge".

12. **Tatarstan**: Migrant birds were recorded in the Belaya River delta (55°50'N, 53°30'E) close to the border with Bashkiria on 4 October 1956 (one bird collected by S. PRIKLONSKII (ZATSEPINA 1978) is listed below for Bashkiriya). A "breeding pair" (note: only the ♀ cares for the brood!) was discovered not far from this point near Stepnoi Zay village, Zainskii District (55°30'N, 51°40'E) on 30 June 1994 (AS'KEEV & AS'KEEV 1994).

13. **Perm Region**: TEPLOUKHOV (1912) mentioned Aquatic Warbler from Il'inskoe on the Obva River (58°30'N, 55°40'E), Perm region, as a common species. One specimen was collected here on 17 September 1922 (VORONTSOV 1949). VORONTSOV (1949) believed that it is an "occasional species" in the region and doubted data of USHKOV (1927), who regarded it as locally common citing TEPLOUKHOV (1912). SAMARIN (1959) was looking for Aquatic Warbler, but found it only once, on 28 September 1957 (locality unknown). Recently some new data were collected for this region. Only once in the last decades was Aquatic Warbler found to be "common" in the vicinity of Perm in summer 1992; this place was destroyed by drainage and peat excavation before 1998 (BAUMUNG, FLADE, KALYAKIN). Furthermore, a group of singing ♂ was observed on the In'va River near Monga village (59°N, 55°30'E), two birds were caught in mist nets (LAPUSHKIN *et al.* 1995).

We also have recent information about Aquatic Warbler in four regions of South Ural from I. KARYAKIN (1997; unpublished manuscript "The Aquatic Warbler in Ural Region"; methods of data collection are not described in the manuscript, so we think it needs confirmation): the species can be common in suitable habitat in some years almost over the whole Perm region, from its southern border to the delta of the Kosa River (c. 60°N); records are mentioned for all small river valleys leading into Kama Reservoir and for mires at the periphery of Kama river valley as well as some other rivers south of Perm. Groups of 5-8 singing ♂ were found in 1994-1995. The population density was larger in areas west of Kama Reservoir.

In early June 1998, the German-Russian expedition (see above) did not find any Aquatic Warblers at these sites !

14. **Bashkiriya** (Bashkortostan Republic): KARYAKIN recorded the species only in the north of the Republic, where groups of 5-8 ♂ were found during breeding season along the Bui River, near Karmanovo Reservoir, in the delta of the Bol'shoi Tanip River and along the Yuruzan' River on the Umiskoe Plateau (55°N and further north).

4.4.2. Western Siberia

In western Siberia, the Aquatic Warbler was mainly recorded in Sverdlovsk/Chelyabinsk (eastern South-Ural region) and Novosibirsk/Tomsk (middle Ob) regions, but the occurrence seems to be irregular and additional research is needed especially in the middle Ob region. Although recent and continuous data from single sites over several years are lacking, RAVKIN (1993) and RAVKIN *et al.* (1997) believe that the total west Siberian population consists of 4,000-22,000 birds (which means 2,000-11,000 ♂ according to RAVKINS census method).

The documentation of KALYAKIN (1998, unpublished) contains the following information about possible breeding:

1. **Sverdlovsk (Ekaterinburg) Region**: There are no data prior to 1994-1995 (KARYAKIN 1997): In those years Aquatic Warbler was found in the southwest of the region in the valleys of Upha and Bisert' Rivers (more than 6 records of groups of ♂, two or more nests with nestlings in late spring and early summer) and in the southeast of the region (two or three records of ♂; 56-57°N).

2. **Chelyabinsk Region**: Some adults and juveniles were obtained near Metlino and Tyubuk (c. 56°N, 61°E), northeast part of the region, in 1872 (SABANEEV 1874; MENZBIR 1895). According to KARYAKIN, Aquatic Warbler inhabits the northern part of the Region up to the Uyi River valley in the south (55-56°N). He believes that this population is the largest in the whole Ural region. Groups of 5-6 to 25 singing ♂ were registered here in 1994-1995 with maximum density of up to 40 ♂ per km² (note: this area was under strong influence of nuclear contamination after 1957; SOKOLOV & KRIVOLUTSKY 1998). In general KARYAKIN concludes that the species is not so rare in South Ural, but it is impossible to estimate the total number due to its nomadic character (there are no local populations known which can be confirmed at one place for several consecutive years). KARYAKIN notes that years with moderate levels of precipitation are more favorable for the Aquatic Warbler. Some data on breeding biology of the species are also presented in his manuscript.

3. **Tyumen Region**: A single bird was seen on 30 July 1991 in an open marsh near the villages Uki, Gorno-Slitkino and Missiya, Uvat District (58°43'N, 68°42'E; BOBKOV *et al.* 1997).

4. **Novosibirsk Region**: The species was regularly found at low density in Chulim, Vengerovo, Kargat, Barabinsk and Chani Districts (54-56°N, 76-81°E) in the beginning of the 1960s (PUKINSKII 1969): a ♀ was collected near the nest on 14 June 1961, three ♀ with brood patches and enlarged ovaries were collected during 5-10 June 1962, and two fledglings were caught on 7 July 1962, all in Vengerovo District; a nest with four nestlings was discovered on 8 June 1962 in Kargat District. The species was mentioned as a rare, occasional breeder in the south of the Region at the Kharasuk river (53°50'-54°N, 78-79°E) during the 1970s (DANILOV & MIKHANT'EV 1976). A breeding group of one ♂ and four ♀ was discovered near Shelkovichikha rain station (55°N, 82°30'E), 42 km west of Novosibirsk, in June 1982 (BALATSKY 1992). Four nests with clutches were found that year, but the species was not recorded there in other years from 1971-1988. TOTUNOV caught some Aquatic Warblers at Chani Lake (c. 53°N, 77°E) in the early and late 1970s (RAVKIN 1993). One bird was recorded near the villages Ukrainka and Ostaninka (56°43'N, 78°18'E, northern Novosibirsk Region) on 17 August 1993 (BOBKOV *et al.* 1997). A joint Russian-German expedition (FLADE, KALYAKIN, TSIBULIN and co-workers) in June 1999 did not find any Aquatic Warbler in the northern Novosibirsk region.

5. **Altai Region**: Aquatic Warbler is known from the region by one specimen collected by A. VELIZHANIN near Barnaul (53°20'N, 83°40'E; Ob' river valley, not far from Novosibirsk) on 28 June 1901 (JOHANSEN 1954).

6. **Tomsk Region**: The Aquatic Warbler was discovered by P. PANTELEEV "in the Ob' river region subtaiga low marsh", as a common species with a density of 5 birds per km² in June 1960 (RAVKIN 1993). The most abundant population was found in the Shegarka mire, middle Ob' river valley (56°25'N, 84°20'E) 50 km west of Tomsk, southern Tomsk Region, in summer 1967 (RAVKIN 1973). Density of birds was estimated as follows (individuals per km²): 141 on 28 May, none on 11 June, 53 on 27 June, 205 on 8 July, and 220 on 20 July. In addition the species was "common" 9 km north from the place mentioned above (density estimated as 36 birds per km² on 21 July 1967). Some specimens were collected (cited as being kept in the Museum of the Zoological Institute of Russian Academy of Science, Novosibirsk, and in the Zoological Museum of Tomsk University; RAVKIN 1973; Note: A. YURLOV, a curator of zoological collection of the Novosibirsk Institute, has informed KALYAKIN that no Aquatic Warbler specimens are in this collection). Later, the Aquatic Warbler was not found at the same places with one exception: two ♀ with alarm calls on 4 July 1974 (GYNGAZOV & MILOVIDOV 1977). The joint Russian-German expedition in 1999 (s. above) did not find any Aquatic Warbler in those mires, although they especially investigated the Shegarka mire.

4.5. Hungary

The only known breeding population in Hungary is in the Hortobágy National Park, where the species has increased from 19 singing ♂ in 1971 to 586 singing ♂ in 1997. A monitoring scheme has been in effect for 18 years, longer than in any other country. There may be further small populations still to be discovered in Hortobágy. Detailed information on population development, habitat, threats and conservation status is presented by KOVÁCS & VÉGVÁRI (1999, this issue).

The species is strictly protected under the Hungarian law for the conservation of nature and is listed as Endangered in the Hungarian Red Data Book.

4.6. Lithuania

A systematic survey in 1995-1997 (Z. PREIKSA, unpublished report) mainly in the central and western parts of the country revealed 8 localities with 250-380 singing ♂ in total, with main breeding sites along the Curonian Lagoon, especially in the Kairiai area (200-300 singing ♂), the Nemunas delta Regional Park (c. 50 ♂) and the Zuvintas Biosphere Reserve (decrease from c. 25 in 1986 to 10-15 ♂ in 1990-1995).

Overall, vegetation succession due to cessation of cutting (or other appropriate management like controlled burning) is the most important threat (Zuvintas, Kaunas reservoir), followed by changes in water table (Nemunas delta). Cutting of vegetation in the breeding season has been identified as a problem for Aquatic Warblers in the Nemunas delta Regional Park (P. MIERAUSKAS, Z. PREIKSA pers. comm.). A management plan has recently been prepared for Nemunas delta Regional Park and now

needs implementation. An initial study must be carefully carried out at the key site of Kairiai with the goal of preparing a habitat management plan. More proper surveys are still needed in the eastern parts of the country, because some more suitable breeding habitat is known to exist there.

The Red Data Book of Lithuania classifies the species as 'insufficiently known' (PALTANAVICIUS 1992). Most breeding sites are within protected areas. The breeding area at Kaunas reservoir should be included in Kaunas Marios Regional Park.

4.7. Germany

The remaining Aquatic Warbler population in Germany is the westernmost and smallest of all the European countries. In 1998 there were only two isolated breeding sites, both close to the Polish border: near Greifswald (19-30 ♂, SELLIN 1984, 1989, 1990) and in the polders of the lower Odra river near Schwedt and Friedrichsthal (17-34 ♂, latest information in RYSLAVY 1997, 1998). The two sites are separated by c.100 km and numbers (in total 40-50 singing ♂) have been stable in recent years (with the exception of 1998 in the lower Odra polders, where as a result of strong summer flooding in 1997 only 7-9 singing ♂ and two nests were recorded, S. FISCHER pers. comm.). Both populations are considered to be satellites of the nearby Polish (West Pomeranian) breeding population and are judged not to be self-sustaining.

In the early 20th century, the Aquatic Warbler was widespread over the whole of northern Germany and quite common in some large fen mire areas, e. g. around Lake Dümmer (Lower Saxony), Havelländisches Luch and Rhinluch (Brandenburg), and Peene river valley (Mecklenburg-Vorpormmern). The species disappeared due to habitat destruction by drainage and land reclamation, mainly during the 1950s to 1970s (WAWRZYNIAK & SOHNS 1977, SCHULZE-HAGEN 1991).

The Aquatic Warbler is classified as 'Endangered' in the German Red Data Book and is legally protected. One of the sites is within the Lower Odra Valley National Park and the other within the Freesendorfer Wiesen Nature Reserve. Small and varying numbers of singing ♂ occur outside protected areas (SCHULZE-HAGEN & WAWRZYNIAK 1993).

4.8. Latvia

A special search for breeding populations of Aquatic Warbler in 1997 at the 10 most promising sites of the country remained unsuccessful (O. KEIŠS, unpublished report), although some areas with suitable habitat were found. Thus, Aquatic Warbler is unlikely to be a regular breeding bird in Latvia.

The species is listed as 'Rare' in the Latvian Red Data Book, having formerly been recorded breeding at four coastal wetland sites: Lake Pape and adjoining marshland, Lake Liepaja, Bog Sarnate/Uzava and Lake Kanieris (VIKSNE 1994). There are 33 confirmed records from the second half of the 20th century and further unconfirmed reports, but only one case of proven breeding from the 1940s at lake Pape. Lake Pape is a shallow lake separated from the sea by a spit of dunes. Due to the absence of cattle grazing since the 1960s, meadow areas surrounding the lake have decreased significantly; in the recent past there was cattle grazing and reed cutting, which influenced the succession of vegetation, but this is being abandoned now (EUCC 1993).

4.9. Regular occurrence on migration in Europe

4.9.1. United Kingdom

Southern Britain lies within the autumn migration corridor. The species is recorded almost exclusively in autumn, chiefly in southern England. Numbers were apparently rather constant to at least 1985, despite the population decline (CRAMP 1992). A national action plan is already in preparation by RSPB and English Nature. The species is not included in the U.K. Red Data Book (BATTEN *et al.* 1990).

4.9.2. Belgium

On migration, the Aquatic Warbler occurs regularly in coastal wetlands (reedbeds) in late summer and autumn. From 1988 to 1998 between 7 and 84 birds have been caught and ringed annually in Veurne, in total 351 birds (N. ROOTHAERT, pers. comm.). In Zeebrugge, from 1987-1990 between 11 and 145 Aquatic Warblers were caught and ringed annually, in total 272 birds (T. DE SCHUYTTER, pers. comm.). In 1990, for instance, 229 Aquatic Warblers were caught at both sites together. [Note: nocturnal migrants are tape-lured at Belgian ringing stations, thus numbers are not comparable with ringing stations where this practice is not allowed].

4.9.3. France

Large reedbeds on the coast (Channel, Atlantic and Mediterranean) and inland are regularly used during migration. The species is more numerous during autumn passage than in spring. The numbers of birds ringed has remained fairly stable despite an increase in the ringing effort (EURING ACRO PROJECT). Numbers varied between 110 and 200 individuals caught each year.

4.9.4. Spain

Aquatic Warbler, which does not have any protection nor legal status in Spain, occurs strictly on migration, and has been recorded both in spring and autumn, but more abundantly during autumn migration. Stop-over habitats included coastal wetlands on the Atlantic and Mediterranean coasts. The Ebro valley acts as a connection corridor between both migration routes (ATI-

ENZA & PINILLA, pers. comm. 1998). In the reedbeds of the Moro marshes (Mediterranean coast) the species occurs regularly during spring migration (up to 8 birds caught and ringed within one week), individuals often staging for one or two weeks; stop-over birds sing actively and, at least in some years, perform a partial moult (M. Y. BLASCO, pers. comm.).

4.9.5. Bulgaria

The Aquatic Warbler occurs regularly on spring and autumn migration, preferentially in the coastal region of NE-Bulgaria. Notes about breeding proved to be unreliable (e.g. about possible nesting in grassy gardens at the edge of villages and towns, KUZNETSOV 1967 cited in NANKINOV 1995). There is no evidence for breeding in the country (P. IANKOV pers. comm.). NANKINOV (1995) published a summary of records in Bulgaria. Most observations and captures are from the period 1976 to 1988. A total of 401 Aquatic Warblers have been ringed, most of them from August to October. A small peak occurs also in May (earliest records about 20 April). The maximum of birds caught for ringing in a single year was 186 in 1977 and 118 in 1980.

5. Conclusions and prospects

The Aquatic Warbler is the only passerine bird in Continental Europe which is classified as globally threatened ("Vulnerable", COLLAR *et al.* 1994). It is listed as 'Insufficiently Known' in the IUCN Red List of Threatened Animals (GROOMBRIDGE 1993). At the European level it is classified as 'Endangered' (TUKKER & HEATH 1994). Because of its specialised habitat requirements, the Aquatic Warbler can be regarded as an ideal flagship species of its habitat, the sedge fen mires, which are also globally threatened. Such fen mires have always been confined to the temperate belt of continental Europe and some parts of southwest Siberia, but were almost totally destroyed in western and west-central Europe by drainage for land reclamation. Open fen mires have also drastically decreased in the former and current core area in eastern Poland and the Belarusian and Ukrainian Polessye, where the area of suitable habitat declined by 80-90 % within the past 30 years. The current situation in western Siberia is still unclear and urgently needs investigation.

Looking at the major threatening factors, we have to consider that the direct destruction of habitat has recently slowed down, but was replaced by accelerated habitat loss due to vegetational succession (overgrowing of fen mires by willow shrubs, birch and alder forests). This results from abandonment of traditional farming practices such as hand-scything, grazing and winter burning in combination with alterations of the water regime.

The remaining Aquatic Warbler population is highly vulnerable due to its concentration in only a few large mire tracts. Currently there are less than 40 constant breeding areas with more than 10 singing ♂ each in the whole of Europe. Fig. 3 reveals that the mires of the upper Pripyat river system hold more than 40 % of the known (European) population, followed up by Yaselda (22 %) and Biebrza/Narew (13 %). All three river systems hold about 80 % of the European population. About 85 % are concentrated within an isosceles triangle with an edge length 250 km in eastern Poland and western Polessye. This means that the species is highly vulnerable to habitat alterations and to exceptional climatic events in this core area. The populations of Pripyat and Yaselda have only been discovered in 1995-1998 at a stage, when mire destruction, drainage campaigns and habitat loss due to abandonment and succession were still rapidly going on.

Due to the surveys performed recently and strongly intensified conservation activities since 1995, mainly in Belarus, Poland and Ukraine, the most important breeding sites are now protected areas (e.g. Biebrza, Lublin/Chelm marshes, Sporova mire, parts of Zvanets and Dikoe) or will likely be included in reserves in the near future (e.g. remaining parts of Dikoe, Yaselda, Zvanets, upper Ukrainian Priyat). Public awareness of the bird and the habitat it requires has been raised considerably, mainly in Belarus, Ukraine and Poland.

Despite of this progress, a major conservation problem is still unsolved: The sound management of hydrologically altered large fen mires. This requires the restoration of a natural hydroregime and/or the maintenance of traditional farming practices, or the substitution of hay cutting by controlled burning and active removal of shrubs. Well-founded management plans have to be elaborated and implemented as quickly as possible.

According to the Aquatic Warbler Species Action Plan of BirdLife International (first version: HEREDIA *et al.* 1996; updated version: AQUATIC WARBLER CONSERVATION TEAM 1998, unpublished), the following major conservation actions are recommended (summary version):

1. Action should be taken to ensure that the Aquatic Warbler receives the fullest possible legislative protection in all countries within its range.
2. Steps should be taken to ensure that in all range states effective national legislation is in place to protect Aquatic Warbler breeding habitat, including the prevention of potentially damaging drainage, e.g. for local water supply, mineral extraction, industry, etc.
3. It is essential to seek policies that enable people to maintain traditional methods of farming while still enjoying a reasonable standard of living. Na-

tional or supra-regional agricultural land-use policies that increase incentives for damaging management of Aquatic Warbler habitat should be opposed or modified.

4. Protection of Aquatic Warbler sites including appropriate management should be encouraged. When designating protected areas, the protection of buffer zones around Aquatic Warbler core sites should be considered.
5. Management plans for the protected areas should be produced, taking into account the species' habitat requirements. These areas should be provided with sufficient human resources and equipment for their adequate management.
6. Drainage, water extraction and other kinds of detrimental water management should be avoided. Burning should also be controlled and peat fires prevented.
7. Regulate water levels and restore natural water conditions where drainage and canalisation have had a severe impact on the wetlands. Sound water management and restoration of natural water conditions can substitute other management techniques like cutting or burning.
8. Natural succession of the vegetation should be prevented by management measures where necessary. To maintain suitability for Aquatic Warblers, several thousand hectares of breeding habitat require active management, especially in unflooded areas.
9. Traditional farming practices at breeding sites should be maintained and promoted. These methods of traditional low-intensity farming are necessary at sites, where drainage and eutrophication affect the mire and vegetational succession (intrusion of bushes or reeds) takes place.
10. Fire can be a very effective management tool though its effects are still poorly understood in detail. While considered to be beneficial, further study is needed to assess the effects on invertebrates and the ecosystem in general. Larger bushes are not controlled by this sort of burning and should be removed by hand.
11. Uncontrolled fires should be stopped. This requires the employment of wardens and local farmers in early spring to control burning.
12. All sites in Europe used regularly by birds on passage should be protected. Development proposals that could have a detrimental effect on these sites should be opposed or modified, e.g. if they have the potential to damage or destroy habitat, cause pollution, or increase disturbance.
13. Monitoring programmes should be implemented according to the methods used in Poland and Belarus, enabling population trends to be followed. For long-term monitoring of important mires, one plot of at least 100 ha at each key site should be investigated with 2-3 visits per year over the whole breeding season.
14. National surveys should be undertaken (or continued) to estimate breeding population. Such surveys should be co-ordinated internationally over a period of five years from 1997. Although surveys in European Russia, Siberia and some parts of Ukraine are needed particularly urgently, the surveys in all other countries within the range should be continued.
15. The major wintering areas should be identified (by ringing in the breeding grounds and on migration, and by mist-netting at potential wintering sites).
16. Comparative studies on breeding success and population recruitment in different habitats should be undertaken (breeding biology is quite well studied at some sites but there is not much information from other areas and especially different mire types, i.e. different trophic level of habitats).
17. An international working group should be set up to investigate potential burning techniques, taking into account the danger of peat fires, and also to study effects of restoration of mires on Aquatic Warbler.
18. Being Europe's rarest migratory passerine, the Aquatic Warbler should be used as a key species for the inventory and protection of fen mires and wet meadows. It should be elected as "bird of the year" in several range states simultaneously, as a means of increasing awareness and for fund raising.
19. Information and educational services to the public should be provided in protected areas. These should include leaflets, stickers, T-shirts, etc. A promotional film about the species and the areas where it lives should be produced, and the inclusion of Aquatic Warbler sequences in nature films and documentaries should be promoted.
20. Genetic studies should be carried out investigating the rate of exchange between the more or less isolated sub-populations.

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6. Zusammenfassung

Aquatic Warbler Conservation Team 1999: Weltpopulation, Bestandsentwicklung und Gefährdungssituation des Seggenrohrsängers *Acrocephalus paludicola.* Vogelwelt 120: 65 – 85.

Der Seggenrohrsänger ist eine global bedrohte Art. Sie brütet noch in Belarus (Weißrussland), Polen, Ukraine, Russland, Ungarn, Litauen und Deutschland. Die europäische Bestand wurde 1997/98 auf 13.500-21.000 singende ♂ geschätzt (Übersicht in Tab. 1), mit Vorkommensschwerpunkten in Belarus (Tab. 2), Polen (Tab. 3) und Ukraine (Tab. 4). Möglicherweise existiert eine weitere, isolierte Brutpopulation von mehreren Tausend Vögeln (die Schätzungen reichen bis zu 11.000 singende ♂) in Westsibirien, jedoch fehlen derzeit aktuelle und zuverlässige Daten zu diesem Vorkommen; die vorhandenen älteren Daten sind sehr heterogen und z.T. widersprüchlich. Der Seggenrohrsänger ist zur Brutzeit auf große, offene Seggenmoore und Schneideried *Cladium mariscus*-Sümpfe spezialisiert. Aufgrund von Habitatzerstörung (Entwässerung und Melioration der Niedermoore sowie Torfabbau) hat die Art in ihrem gesamten Verbreitungsgebiet im Verlaufe dieses Jahrhunderts stark abgenommen. Im verbliebenen Kerngebiet der Verbreitung in der ukrainisch-weißrussischen Polessje ("Pripjetsümpfe") sowie den angrenzenden Gebieten Polens ist ein flächenhafter Rückgang von intakten Niedermooren um 80-90 % innerhalb der letzten 30 Jahre zu verzeichnen. Derzeit wird die direkte Lebensraumzerstörung durch Entwässerung und Melioration fortgesetzt. Habitatverluste infolge von Sukzession (Verbuschung und Überwachsen der Moore mit Gehölzen), die wiederum durch Nutzungsaufgabe und großflächige Veränderungen des Wasserhaushalts verursacht wird, beschleunigen den Prozeß. Der verbliebene Seggenrohrsängerbestand ist hochgradig gefährdet und verletzbar, weil er sich im wesentlichen auf einige wenige große Moorkomplexe konzentriert. Zur Zeit gibt es in ganz Europa weniger als 40 regelmäßig besetzte Brutgebiete mit mehr als 10 singenden ♂. Die Talmoore der drei Flusssysteme von oberem Pripjet (40 %), Jaselda (22 %) und Biebrza/Narew (13 %) beherbergen zusammen 80 % der europäischen Population. Die Hauptbrutgebiete an Pripjet und Jaselda wurden erst 1995-1998 entdeckt, zu einem Zeitpunkt als Moorzerstörung, Entwässerungsprogramme und Lebensraumverluste durch Nutzungsaufgabe und Sukzession noch in vollem Gange waren. Beginnende Naturschutzaktivitäten wie Unterschutzstellungen und die Aufstellung von Managementplänen haben erst begonnen und konnten der Rückgang der Art bisher nicht stoppen.

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The breeding system of the Aquatic Warbler *Acrocephalus paludicola* – a review of new results

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Schulze-Hagen, K., B. Leisler, H. M. Schäfer & V. Schmidt 1999: The breeding system of the Aquatic Warbler *Acrocephalus paludicola* – a review of new results. Vogelwelt 120: 87 – 96.

Since 1991/1992 (SCHULZE-HAGEN 1991; CRAMP & BROOKS 1992) much has been contributed to the understanding of the breeding system of the Aquatic Warbler, a species with a mating system showing elements of scramble competition, polygyny and promiscuity. The species has been studied by our Polish-German working group in a 48 ha area in the southern basin of the Biebrza valley, NE Poland, since 1984. With the help of radio telemetry it was possible to show that ♂ cover home ranges of up to 7.8 ha. Home ranges may overlap widely and are frequently shifting. Core areas are occupied more intensively but not constantly (SCHÄFER 1998). The ♂" mobility correlates negatively with the number of fertile ♀ present, and non-aggressive searching for ♀ was more pronounced when fewer fertile ♀ were available. Song activity did not vary seasonally but showed marked diurnal peaks with a maximum between 18.00 h and 22.00 h. After sunset, short A-songs are performed, mainly for intrasexual communication and ♂ spacing. Our molecular analyses revealed that more than 60 % of the broods are fathered by 2 to 4 ♂. Hatching success in mixed paternity clutches was sometimes higher than in broods sired by a single ♂. In captivity, the duration of copulation averages 24 min, which is extraordinarily long and can be regarded as a kind of contact mate guarding. Very large cloacal protuberances, testes and seminal glomera with a high number of sperm are ♂ adaptations to intense sperm competition. Short breeding intervals, long brooding phases, short foraging flights and high feeding frequency as well as a lower growth rate of nestlings seem to be related to uniparental care by the ♀.

Key words: *Acrocephalus paludicola*, breeding biology, mating systems, promiscuity.

1. Introduction

To be able to protect the globally threatened Aquatic Warbler, information is needed concerning the species' habitat requirements and breeding biology. Research and conservation stimulate each other and are now inseparably interwoven. This is the special contribution of Prof. A. DYRCZ who, by his untiring research activities in Poland, has made the Aquatic Warbler a flagship species for the endangered flora and fauna of fen mires in European nature conservation.

For 15 years, our Polish-German working group has carried out studies on the Aquatic Warbler's breeding biology at the study site in the southern basin of the Biebrza valley, NE Poland. The principal share of the field work was done by Andrzej DYRCZ and his co-worker Wanda ZDUNEK. The species' accounts published in the "Handbuch der Vögel Mitteleuropas" (SCHULZE-HAGEN 1991) and in CRAMP & BROOKS (1992) summarise the knowledge at that time. Apart from the two seminal studies of HEISE (1970) and WAWRZYNIAK & SOHNS (1977), the knowledge about breeding biology is based on research of our team (DYRCZ 1989; LEISLER 1981, 1985, 1988; SCHULZE-HAGEN *et al.* 1989). Since 1991, a series of studies was published revealing new aspects of the biology of this promiscuous passerine. This review summarises the new results published since 1991/92 as well as some recent unpublished findings which contribute to a better understanding of the Aquatic Warbler's reproductive biology.

2. Study sites and methods

The 48 ha study plot (Grobla Honczarowska, 53°20' N, 22°40' E) is part of a fen mire in the non-flooded zone 5-6 km from the river Biebrza. The dominant plant species is *Carex appropinquata*, forming tussocks of varying height. Other *Carex* species *(C. elata, C. rostrata* and *C. limosa)* dominate in mossy areas *(Caliergonella cuspidata, Drepanocladus intermedius* and *Bryum ventricosum)*. The height of sedges does not exceed 80 cm while water level is 5-25 cm. Small *Salix* bushes (1-1.5 m) are scatte-

red throughout. Extensive hay making had ceased in this area during the early 1970s. The plot divided into 100 x 100 m squares with coloured poles and into 50 x 50 m squares for the radio tracking study. The whole area of Biebrza marshes was declared a National Park in 1993 (SCHÄFFER 1996).

Since 1986, the number of singing ♂ has been censused and nests were searched. All ♂, ♀ and nestlings were colour-ringed, and, in several years (1990, 1993, 1994, 1997), blood samples were taken from adults and young for molecular analyses (DNA-fingerprinting, microsatellite-PCR). Intensive observations (partly from a hide) shed new light on territorial behaviour and song activity of the ♂ as well as on breeding and feeding activity of the ♀. In 1990 and 1993 songs were recorded and analysed spectrographically. After a pilot study in 1996, in 1997 25 ♂, and in 1998 three ♂ and ten ♀ were equipped with small radiotransmitters (SCHÄFER 1998). Continuous direct observation of the birds is hampered by the dense vegetation of their prefered habitat, which allows a range of visibility of only up to 20 cm, and by the skulking behaviour of the birds, particularly the ♀ prior to the breeding period. Like rails, Common Quail *Coturnix coturnix* or *Locustella* warblers, Aquatic Warblers remain virtually completely hidden from the observer. Therefore, it was necessary to hand-raise several nestlings and keep them in aviaries under semi-natural conditions for close observations.

3. Short summary of knowledge up to 1991

The Aquatic Warbler's mating system differs from that of other *Acrocephalus* species in that the ♂ are completely emancipated from brood care and no pair bond is established. Breeding and feeding of the young is done exclusively by the ♀ (i.e. uniparental care; HEISE 1970; DYRCZ 1989). ♂ seem to be continuously ready to mate and are testing every ♀ for her willingness to copulate (SCHULZE-HAGEN 1991). Up to three nests were found in close proximity to song posts used for a longer period by individual ♂, which suggested a kind of resource defence polygyny (food, nest sites; LEISLER 1985; DYRCZ 1989).

The ♂ use home ranges in the homogeneous, dense, tangled vegetation intensively, and obviously do not defend them (WAWRZYNIAK & SOHNS 1977; DYRCZ 1989). The core areas of individual ♂ are about 0,11 ha (1100 m²) and may partially overlap in optimal habitats (LEISLER 1985). In such habitat, densities of 9.5 to 12 singing ♂ are found per 10 ha (DYRCZ *et al.* 1984). Aggressive interactions between ♂ have rarely been observed.

Unlike ♂ in species with biparental care, Aquatic Warbler ♂ do not restrict their song activity to the early reproductive period, but sing with the same intensity throughout the whole breeding season. However, diurnal variation of song activity is pronounced showing a maximum at dusk when virtually all ♂ of a population are singing simultaneously. The song is short and simple and consists of three song types: A-song (rattles) mainly signals aggression and warning, B-song (introductory rattles followed by a sequence of tonal units) is an intermediate form, and C-song, which is longest and most complex, has a sexual function (CATCHPOLE & LEISLER 1989). Short song flights are performed mainly in the daytime (WAWRZYNIAK & SOHNS 1977).

The ♀ forage in immediate proximity to the nest (flights in a range of 10 to 50 m) and take mainly large prey, particularly spiders, caterpillars, Coleoptera, Diptera and Trichoptera (SCHULZE-HAGEN *et al.* 1989). The prey taken may vary greatly and is contingent on annually and seasonally changing food supply. Feeding frequency is high due to the habitat's richness in food. Low nest predation and a 50 % rate of second broods in some years guarantee a high reproductive output (WAWRZYNIAK & SOHNS 1977).

4. New results obtained after 1991

4.1. Arrival at breeding site, home ranges of ♂ and song

From the first observations of singing ♂ and the earliest egg-laying dates it can be inferred that the sexes arrive about simultaneously at the breeding site

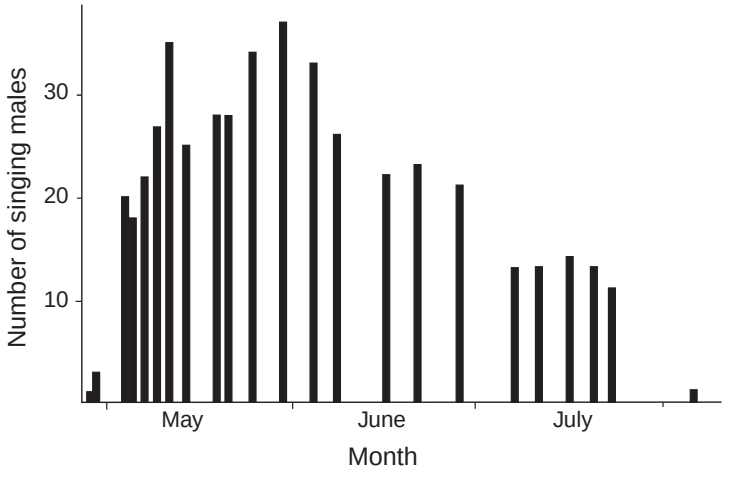

Fig. 1: Changes in abundance of singing ♂ Aquatic Warblers in a 48 ha study plot in Biebrza Marshes, Poland (from DYRCZ & ZDUNEK 1993b). – *Saisonale Änderungen der Zahl singender Seggenrohrsängermännchen auf einer 48 ha-Probefläche in den Biebrza-Sümpfen, Polen (aus DYRCZ & ZDUNEK 1993a).*

(DYRCZ & ZDUNEK 1993a). The number of singing ♂ in the study area increases continuously from the end of April to the end of May and afterwards decreases gradually up to the end of July (Fig. 1). Based on long-term observations of colour-ringed ♂, "territory size" in optimal habitats is 1.3 ± 0.82 ha (Fig. 2).

A radio telemetry study on 25 ♂ carried out in 1997 (SCHÄFER 1998; SCHÄFER *et al.* in prep.) revealed much more detailed information on the males' activity ranges. ♂ do not defend territories but hold overlapping home ranges (up to 74 % overlap; Fig. 2). Home ranges of up to 7.8 ha occur, which is distinctly larger than the "territory size" assessed previously by mere observation. Up to eleven radio-tracked ♂ were found within the home range of a single ♂. Some song posts are reported to be used by up to four ♂ successively. Yet, half of the time, the ♂ stay in isolated sections of 0.5 to 1.2 ha, which is only 16 % of the entire home range. These core areas overlap with the home ranges of other ♂ to a much smaller extent. They are used for 3 to 8 days on average and shift continuously throughout the breeding season (Fig. 3). Strikingly, ♂ frequently change their activity ranges. Mean duration of the male's presence at the study site was only 25 days (extremes 1-59 days).

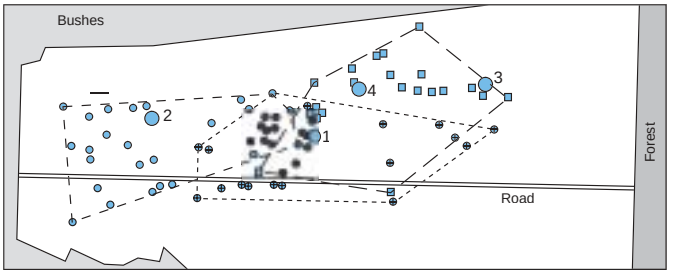

Fig. 2: Location of "territories" and song posts of three Aquatic Warbler ♂ and nests (numbered dots) at a site ca. 8 km distant from the Biebrza Marshes study site (from DYRCZ 1989). – *Verteilung von "Territorien" und Singwarten von drei Seggenrohrsängermännchen sowie Neststandorte (numerierte Punkte) auf einer Fläche, die ca. 8 km von der Probefläche entfernt liegt (aus DYRCZ 1989).*

♂ mobility correlates with the number of fertile ♀ in the area. ♂ cover larger distances and are more mobile when there are only few receptive ♀ available and are less mobile with many fertile ♀ present. ♂ manifest their presence by intensive song. So far, no evidence is available for a relationship between the males' activity ranges and the females' nest sites (SCHÄFER 1998) since fertilisation success of individual ♂ has not yet been analysed.

Daily song activity (time with/without song) of ♂ tracked by telemetry does not change in the course of the breeding season. However, variation within the day is pronounced and reaches a maximum between 18:00 and 22:00 h (SCHMIDT 1998; SCHMIDT *et al.* in prep). The same is true of song rate (i.e. number of songs per unit time), which is at its peak between 2:00 h and 4:00 h and between 20:00 h and 22:00 h. The proportion of C-songs (presumably with sexual function) declines in the course of the season and has a diurnal peak between 18:00 h and 20:00 h. A-song with intrasexual function (♂ spacing) is most frequent after sunset.

♂ reacted in different ways to the playback of A- and C-songs. At the playback of A-song they approached and responded with an increasing proportion of A-songs. However, this reaction was performed only during the first half of the breeding season. ♂ did not show any reaction to the playback of C-song (SCHMIDT 1998). Song flights presumably serve to increase au-

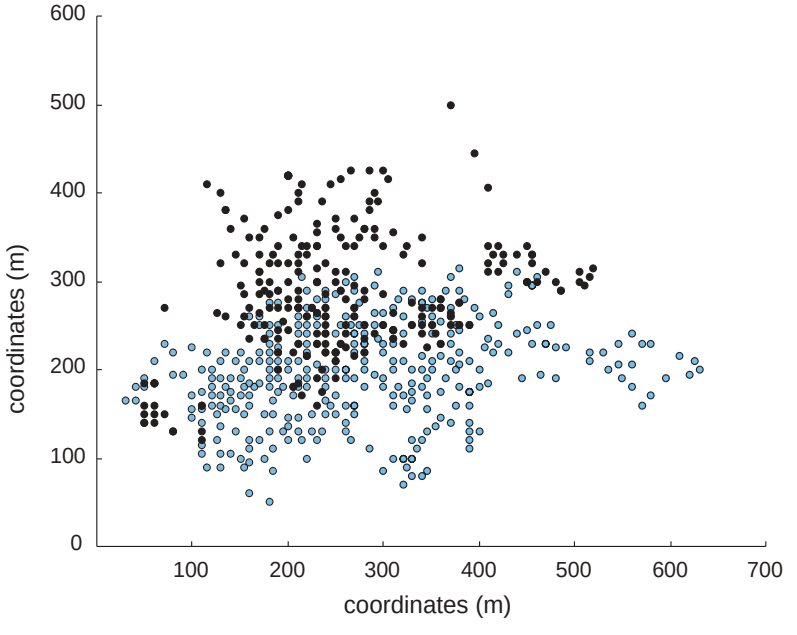

Fig. 3: Seasonal shift of a ♂ Aquatic Warbler home range as revealed by use of microtransmitters (○ records 18.-22. May 1998; ● records 25.-29. May 1998) (from SCHÄFER 1998). – *Beispiel für die saisonale Verschiebung eines Streifgebietes eines Seggenrohrsängermännchens, das einen Transmitter trug* (○ Ortungen 18.-22. Mai 1998; ● Ortungen 25.-29. Mai 1998) *(aus SCHÄFER 1998).*

Fig. 4: Typical song flight of Aquatic Warbler. – *Singflug des Seggenrohrsängers.* Drawing by D. QUINN.

dibility. Frequency of song flights was higher in the middle of the breeding season when the number of fertile ♀ was low. Song flights contained more C- and fewer B-songs than songs given from song posts and were performed more often during the second half of the day (SCHMIDT 1998; SCHMIDT *et al.* in prep.).

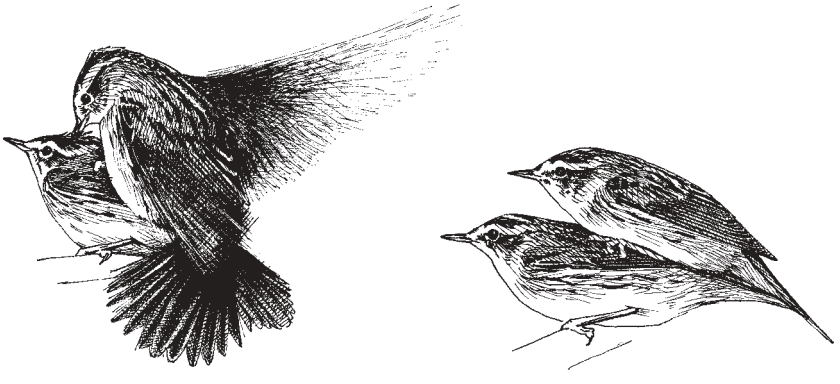

Fig. 5: Left: Copulation in Aquatic Warblers. Cloacal contact during a copulation bout: the fluttering ♂ twists his abdomen towards the female's cloaca for 1-5 sec. Right: ♀ and ♂ resting in close physical contact for several minutes between cloacal contacts (drawings by R. LOTTMANN; from SCHULZE-HAGEN *et al.* 1995). – *Links: Kopula beim Seggenrohrsänger. Der Kloakenkontakt dauert 1-5 sec. Rechts: Zwischen zwei Inseminationen ruhen Weibchen und Männchen für mehrere Minuten in engem Körperkontakt (Zeichnung R. LOTTMANN. Aus SCHULZE-HAGEN et al. 1995).*

4.2. Mating system and reproductive organs

Molecular studies (DNA-fingerprinting from blood samples from ♂, ♀ and nestlings, n = 120) revealed a very high rate of broods with multiple paternity (SCHULZE-HAGEN *et al.* 1993). These results were confirmed with the help of microsatellite PCR of about 315 nestlings from 72 broods and 170 adults from three years (DYRCZ *et al.*, in prep.). On average, 39 % of the broods were sired by one father, whereas 61 % were multipaternal with 2-4 fathers. The proportion of young sired by a second or third ♂ (young of additional fathers) averaged 23.8 %. The rate of multiple paternity was equal in first and second broods, but varied between years, presumably depending on weather conditions, i. e. food supply (DYRCZ *et al.* in prep.). There was no significant difference between single and multipaternal broods in terms of ♀ traits and breeding parameters (e.g. date of the first egg, clutch size etc.). However, there was

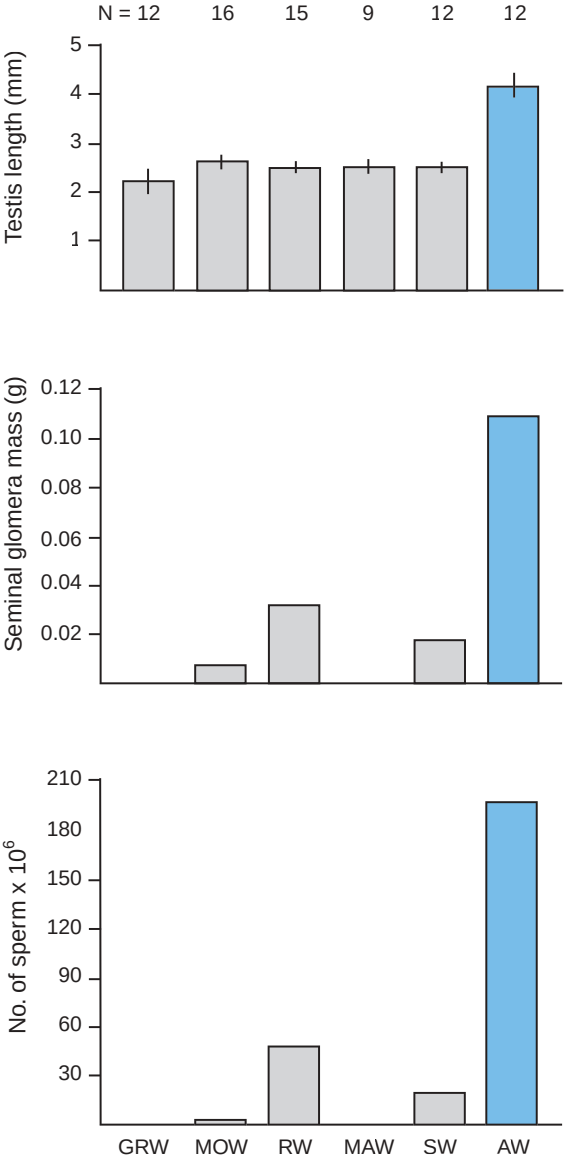

Fig. 6: Comparison of ♂ reproductive anatomy between *Acrocephalus* warblers: GRW Great Reed Warbler, MOW Moustached Warbler; RW Reed Warbler; MAW Marsh Warbler; SW Sedge Warbler; AW Aquatic Warbler. (Top) Testes length (corrected for body mass by dividing by cube root of mass), determined by laparotomy; values are means + s. d. (n). (Middle) Seminal glomera mass; data for single specimens except for the Aquatic Warbler, where n = 2; no data for Great Reed Warbler or Marsh Warbler. (Bottom) Numbers of spermatozoa in the seminal glomera; no data for Great Reed Warbler or Marsh Warbler (from SCHULZE-HAGEN *et al.* 1995). – *Vergleich der Anatomie der Sexualorgane bei Rohrsängermännchen: GRW Drosselrohrsänger; MOW Mariskensänger; RW Teichrohrsänger; MAW Sumpfrohrsänger; SW Schilfrohrsänger; AW Seggenrohrsänger. Oben: Hodengröße (körpergewichtskorrigiert; Messung durch Laparotomie; Durchschnitt und Standardabweichung). Mitte: Gewicht der glomera seminales; Messung jeweils bei 1 Männchen, beim Seggenrohrsänger n = 2; keine Angaben für Drossel- und Sumpfrohrsänger. Unten: Spermatozoenzahl in den glomera seminales; keine Angaben für Drossel- und Sumpfrohrsänger (aus SCHULZE-HAGEN et al. 1995).*

a marked difference in the rate of unhatched eggs and of starved or disappeared nestlings, which was lower in multipaternal broods (DYRCZ *et al.* in prep.).

The promiscuous mating system of *A. paludicola* with a high level of multipaternity indicates intense sperm competition. In choice experiments carried out in aviaries ♀ reacted more promptly and for longer periods to the playback of C-songs than to the playback of A-song (CATCHPOLE & LEISLER 1996), partly performing wing-quivering. Under aviary conditions, the ♂ are trying to copulate continuously during the females' fertile period (SCHULZE-HAGEN *et al.* 1995). ♀ unwilling to copulate will hide in the vegetation. The copulation, in other birds usually lasting only 1-2 sec, is extraordinarily long in Aquatic Warbler (Fig. 5). The ♂ stays mounted for 23.7 ± 11.8 min on an average and has up to 6 cloacal contacts (inseminations). Prolonged copulation may have evolved, on the one hand, to allow ♀ to assess ♂ quality and, on the other hand, to allow ♂ contact mate guarding. Copulations are most frequent some days before egg-laying and during the early laying period with peaks in the evenings and in the early mornings. The ♀ is able to interrupt copulation at any time by escaping the ♂ (SCHULZE-HAGEN *et al.* 1995).

The reproductive organs are also extremely well adapted to intensive sperm competition with cloacal protuberance, testes and seminal glomera being extraordinarily large compared to other *Acrocephalus* species and birds in general (Fig. 6). The numbers of sperm in the seminal glomera is very high, whereas the length of the spermatozoa is not conspicuous (SCHULZE-HAGEN *et al.* 1995).

4.3. Breeding biology

In the aviary, ♀ willing to construct a nest often returned to a selected tuft of vegetation, climbed around and performed movements at its bottom. Soon afterwards they carried nesting material. Nest construction is done mainly in the mornings and in the evenings. It takes about 2 to 3 days to construct the outer layer and two days to line the interior of the nest (SCHULZE-HAGEN 1995).

Clutch initiation is well synchronised within the population. Up to 80 % of the ♀ start egg-laying within one week (DYRCZ & ZDUNEK unpubl.). The nests are not distributed evenly over the study plot but are clustered (Fig 7). Nest sites differ from randomly chosen places in having a higher water level and a larger proportion of dry, last year's grass covering the nest

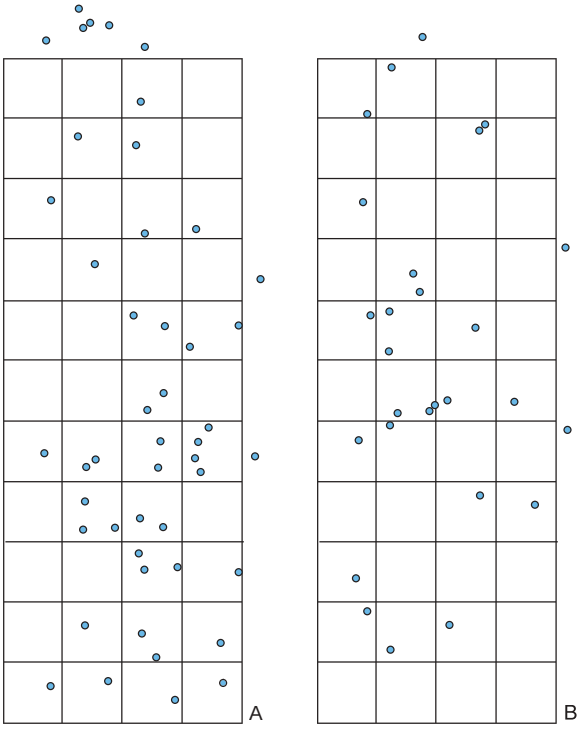

Fig. 7: Distribution of Aquatic Warbler nests on the Biebrza Marshes study plot in 1990 (squares 100 x 100 m); (A) first brood; (B) second brood (from DYRCZ & ZDUNEK 1993a). – *Verteilung von Seggenrohrsängernestern auf der Probefläche 1990. (A) Erste Brut; (B) zweite Brut (aus DYRCZ & ZDUNEK 1993a).*

(DYRCZ & ZDUNEK 1993). Also abundance of prey is of importance in the choice of the nest site: the density of arthropods is distinctly higher in the immediate proximity of the nest than in plots chosen at random. This correlates with the observation that the principal share of the food is collected at a distance of 18 to 30 m from the nest (SCHULZE-HAGEN *et al.* 1989; DYRCZ & ZDUNEK 1993a). Particularly where nests are clustered, density of potential prey is distinctly higher (Tab. 1). In several cases, two nests were situated within less than 10 m of each other. In such cases the foraging areas did not overlap (DYRCZ & ZDUNEK 1993a), while aggressive interactions among foraging ♀ are frequent (SCHULZE-HAGEN 1991).

During the period of incubation, which is performed by the ♀ alone, the time spans of nest attendance and absence are very short, averaging 11 and 5 min, respectively. These are the shortest phases ever recorded in Passerines. They may be interpreted in relation to uniparental care by a small insectivorous bird with a high metabolic rate in an environment with variable microclimate (DYRCZ 1993). Incubation lasts 12 to 14 days (SCHULZE-HAGEN 1995). Compared to other *Acrocephalus* species, feeding activity is lower and brooding more intensive during the first days after hatching. With the beginning of thermoregulatory independence of the nestlings and their rapidly increasing demand for food, brooding decreases from the 7th or 8th day onwards. Feeding frequency now increases markedly and is higher than in Marsh Warblers *A. palustris*, where both parents participate in rearing the young (DYRCZ 1993; SCHULZE-HAGEN *et al.* 1989). With 15 to 16 days, the fledgling period is by far the longest among all *Acrocephalus* warblers and reflects the low feeding frequency during the first days after hatching. Compared to other *Acrocephalus* species, the young show a clearly retarded growth rate (DYRCZ 1993; DYRCZ *et al.* 1994). In one case, two young were still being fed 14 and 16 days after fledging (SCHULZE-HAGEN 1995).

Only 17 % of the ♀ stayed at the study site, where they have bred successfully, to start a second brood. Thus, the majority of ♀ breeding at any time moved into the area a short time before (DYRCZ & ZDUNEK 1993a). Similar movements prior to the start of the second brood also seem to be of major importance elsewhere (WAWRZYNIAK & SOHNS 1977, M. FLADE & A. KOZULIN, pers. com.).

Aquatic Warbler ♀ are very cryptic and shy in the surroundings of their nests, particularly when breeding or during the early nestling period. Only later does the frequency of warning calls at the approach of predators increase. In contrast to Meadow Pipit *Anthus pratensis* and Reed Bunting *Emberiza schoeniclus*, Aquatic Warbler ♀ display less risky antipredatory behaviour such as warning calls from the distance, only minor approaches and

Tab. 1: Comparative abundance of potential prey (dry weight arthropods) in different nesting situations of Aquatic Warblers in 1991; sampling of arthropods by standardised sweep-netting. Aggregated nests < 30 m apart; isolated nests > 50 m from next nest apart (from DYRCZ & ZDUNEK 1993a). – *Beziehung zwischen Nahrungsangebot (Trockengewicht von Arthropoden) und Neststandorten 1991. Proben wurden mit standardisierten Kescherfängen gesammelt (aus DYRCZ & ZDUNEK 1993a).*

site	dry weight (mg)	significance
directly at nest (n=30) within 30 m of nest (n=45)	81.1 ±61.8 107.9 ± 75.0	$t_{73} = 1.62$; n. s.
at nest aggregations (n=15) at isolated nests (n=30)	155.6 ± 61.2 87.1 ± 77.8	$t_{43} = 2.98$; $p < 0.01$
first brood (n=55) second brood (n=20)	111.1 ± 74.0 58.8 ± 43.0	$t_{73} = 6.75$; $p < 0.001$

Fig. 8: Aquatic Warbler. – *Seggenrohrsänger.* Photo: M. WOIKE.

Fig. 11: Aquatic Warbler with typical leg posture, in which they also climb through dense tufts of sedges. Yaselda marshes, summer 1998. – *Seggenrohrsänger in typischer Beinhaltung (mit gespreizten Beinen unterschiedliche Stengel greifend), die auch beim Klettern durch dichte Seggenbüschel häufig zu beobachten ist; Jaselda-Talmoor, Sommer 1998.* Photo: A. KOZULIN.

Fig. 9 and 10: Compared to other *Acrocephalus* species, Aquatic Warblers feed relatively large prey to their young; Yaselda marshes, summer 1998. – *Im Vergleich mit anderen Rohrsängerarten verfüttern Seggenrohrsänger relativ große Beutetiere an ihre Jungen; Jaselda-Talmoor, Sommer 1998.* Photo: A. KOZULIN.

no attacks. In experiments, they approach nearer to small mammals than to birds of prey (HALUPKA 1993). The shy and cryptic behaviour near the nest seems to be related to unaided rearing of the young by the ♀. Whether ♂ begin to sing when potential predators approach the nest has to be clarified. Possibly, this is a weak manifestation of ♂ investment (DYRCZ & SCHULZE-HAGEN unpubl.).

4.4. Breeding statistics

Clutch size amounts to 3-6 eggs with a median of 5 eggs (Tab. 2). First clutches are somewhat larger than second clutches (see appendix). Losses are remarkably small and breeding success is among the highest ever recorded in open nesting passerine birds. Total losses occur in only 20 % of the broods (according to a simple calculation; the MAYFIELD method

appears to yield too low an estimate given the high breeding success of this species (DYRCZ & ZDUNEK 1993b). The percentage of successfully fledged nestlings amounts to 62 % (n = 677 eggs; DYRZC & ZDUNEK 1993b). Losses in first broods are smaller than in second broods. Total breeding success may vary considerably from year to year. It has still to be tested whether breeding success is higher in aggregations or in isolated nests.

Losses during the time of egg-laying and incubation are distinctly smaller than during the nestling phase. The proportion of unhatched eggs (infertile, dead embryo) is 8,6 %. The main causes of losses are predation, flooding, starvation and abandoning of broods. Harriers *Circus* spec. seize nestlings which attract attention by their begging calls in rainy and cold weather (DYRCZ & ZDUNEK 1993b and pers. com.). In one case where the complete brood died from starvation, the ♀ extended its foraging flights to 86 m on average and frequently as far as 200 m, feeding conditions in the approximity of the nest obviously being unfavourable (DYRCZ 1993). Unlike other *Acrocephalus* fledglings, young Aquatic Warblers soon behave in a solitary way. As a response to disturbance they tend to fly upwards, performing high jumps. Both behaviours may be interpreted as anti-predator strategies against small ground-dwelling mammals.

5. Discussion

High productivity of the Aquatic Warbler's habitat is the essential prerequisite for uniparental care by the ♀ and the high degree of ♂ emancipation (LEISLER & CATCHPOLE 1992). Yet, the fact that (1) breeding conditions are unpredictable due to watertable changes (LEISLER 1985), (2) the resources are not economically defendable (SCHÄFER *et al.* in prep.) and (3) ♂ aggregate, resulted in a "lek-like" mating system (WIKELSKI & TABORSKY 1997) or in a sort of scramble competition. Since 1991, particularly molecular genetic techniques and radio telemetry have added much to our understanding of the Aquatic Warbler breeding system. The high frequency of broods with multiple paternity, prolonged copulation and adaptations to high sperm production are all indications of intense sperm competition, which may act as a selection factor (BIRKHEAD 1993; SCHULZE-HAGEN *et al.* 1995; general see PARKER 1970; REYNOLDS 1996). Against this background, the males' far reaching movements and constant song activity throughout the breeding period indicate continuous advertisement and readiness to mate. Prolonged copulation and high sperm production can be seen as the only available strategy of effective paternity assurance. Apparently, receptive ♀ choose nest sites and feeding areas as a function of habitat parameters such as prey availability, which may result in a more scattered or a more concentrated distribution of nests in suboptimal or optimal habitat patches, respectively (DYRCZ & ZDUNEK 1993). On the other hand, ♂ tend to aggregate in places where fertile ♀ are likely to be available. However, whether some ♂ succeed in monopolising access to ♀ still remains unclear. The high degree of synchronisation of egg-laying at the beginning of the breeding period may restrict ♂ access to ♀ in time. In contrast to "classical" systems with scramble competition, the mobility of ♂ is lower when many fertile ♀ are available (SCHÄFER 1998; SCHÄFER *et al.* in prep.). This could mean that fertile ♀ visit advertising ♂ in a given area. Preliminary results from our radiotracking study suggest, that females do some mate sampling and that males may switch between different mating tactics (being mobile or stationary).

Why some ♀ mate with only one ♂, but others mate with several ♂, is still an unresolved question both in terms of the mechanism and the function. A comparison of data from three years with different weather conditions revealed that in 1997, a year with unfavourable weather, not only was the rate of broods with multiple paternity higher, but also the rate of unhatched eggs and of starved/disappeared nestlings was significantly lower in broods with multiple paternity than in broods with single paternity (DYRCZ *et al.* in prep.). Such year-to-year variation will

Tab. 2: Breeding statsitics of the Aquatic Warbler population in the lower Biebrza basin (from DYRCZ & ZDUNEK 1993 a, b; SCHULZE-HAGEN 1991, 1995). – *Brutbiologische Parameter (aus DYRCZ & ZDUNEK 1993a, b; SCHULZE-HAGEN 1991, 1995)*

duration of nest building	3-5 days
laying period	early May until late July
first egg (median)	1st clutch 18 May 2nd clutch: 29 June
clutch size (average) first clutch	5.11 ± 0.60 eggs
clutch size (average) second clutch	4.37 ± 0.60 eggs
total clutch size (average; n = 157)	4.81 ± 0.73 eggs
length of incubation	12 to 14 days
length of nestling phase	15 to 16 days
time feeding fledglings (one case)	12 to 14 days
interval between first and second clutch	41 days
time between loss of clutch and first replacement egg	7 days
rate of second clutches	ca. 50 %
breeding success (% eggs producing fledglings; n = 677)	62 %
unhatched (infertile, dead embryo)	8.6 %
losses during egg stage	11.9 %
losses during nestling stage	30.4 %

offer the opportunity to identify important ecological factors that might influence ♂ and ♀ mating tactics. Whether mate sampling is costly for ♀ and which criteria they use for mate choice is still unknown. Probably variation in the extent of knowledge about potential ♂ partners explains variation in the number of fathers per brood. For example, multiple matings could allow ♀ to correct an initial choice of a partner (in a similar way as in the Common Quail, RODRIGO-RUEDA *et al.* 1997). Alternatively, only some ♀ may succeed in pairing with more than one ♂. Data on the fertilisation success of individual ♂ and their distribution are necessary to test these ideas. Development of additional microsatellite primers to find out which ♂ are sires within one brood and to determine overall fertilisation success of individual ♂ is under way. Benefits which may accrue to ♀ from multiple matings could be fertilisation insurance, genetic diversity or avoidance of negative inbreeding effects. Further study of the molecular structure of different Aquatic Warbler populations in Eastern Europe and further radio tracking studies to assess the spatio-temporal association of the sexes should help to answer these open questions. Simple experiments in the wild are aimed at clarifying whether ♂ warn ♀ about potential predators, a way in which ♀ might benefit directly (DYRCZ & ZDUNEK 1993a). Examination of sperm morphology and physiology as well as the structure of the ♀ genitalia should help to better understand the mechanism of sperm competition.

The comparative analysis of several *Acrocephalus* species with mating systems varying from monogamy to polygyny and promiscuity proved to be especially fruitful for understanding many aspects of the Aquatic Warbler's reproductive biology (LEISLER & CATCHPOLE 1992).

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6. Zusammenfassung

Schulze-Hagen, K., B. Leisler, M. Schäfer & V. Schmidt 1999: Brutbiologie des Segggenrohrsängers *Acrocephalus paludicola* – Überblick über die neuesten Ergebnisse. Vogelwelt 120: 87 – 96.

Neue Forschungsergebnisse zur Brutbiologie des Seggenrohrsängers, die nach 1991 (SCHULZE-HAGEN in GLUTZ & BAUER 1991) gewonnen wurden, werden beschrieben. Die Ergebnisse stammen von einem polnisch-deutschen Team, dass seit 1986 auf einer 48 ha großen Probefläche im Südbecken der Biebrza-Niederung (Nordost-Polen) am Seggenrohrsänger forscht. Telemetriestudien haben gezeigt, dass die Aktionsräume (home ranges) der ♂ bis zu 7,8 ha groß sind, sich oft überlappen und häufig wechseln. Die Kerngebiete der home ranges werden intensiver genutzt. Die Beweglichkeit der ♂ (Häufigkeit und Ausmaß der Ortswechsel) korreliert positiv mit der Anzahl anwesender fruchtbarer ♀. Die Gesangsaktivität hat ihren Höhepunkt während und nach dem Sonnenuntergang zwischen 18:00 und 22:00 Uhr, wenn vorwiegend kurze Strophen des A-Typs vorgetragen werden. Molekulargenetische Analysen haben ergeben, dass etwa die Hälfte aller Bruten von mehreren (2-4) Vätern stammt. Bei in Gefangenschaft gehaltenen Vögeln wurde festgestellt, dass die Kopulation ungewöhnlich lange (im Durchschnitt 24 min) dauert, was als eine Form von "mate-guarding" angesehen werden kann. Die ♂ sind sehr gut an extrem intensive Spermienkonkurrenz (sperm competition) angepasst (sehr große Kloake, Hoden und Samenreservoire sowie eine hohe Spermienmenge). Kurze Bebrütungsintervalle, eine lange Bebrütungszeit, kurze Nahrungsflüge und hohe Fütterungsfrequenz sind ebenso wie verzögerte Nestlingsentwicklung und spätes Ausfliegen der Jungvögel als Anpassungen an die uniparentale Brutpflege anzusehen (Bebrütung und Jungenaufzucht werden ausschließlich vom ♀ übernommen).

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Breeding habitat, abundance and conservation status of the Aquatic Warbler *Acrocephalus paludicola* in Belarus

Alexander Kozulin & Martin Flade

Kozulin, A. & M. Flade 1999: Breeding habitat, abundance and conservation status of the Aquatic Warbler *Acrocephalus paludicola* in Belarus. Vogelwelt 120: 97 – 111.

More than half of the entire population of the globally threatened Aquatic Warbler is concentrated in the south-west of Belarus. When the Belarusian population was discovered in 1995-1997, a strong decline due to mire destruction by drainage and abandonment was still in progress. Since 1995, nearly all potential Aquatic Warbler sites have been investigated and studies on population development, habitat structure, breeding success and diet of the species have been initiated. Belarus holds a population of 7,300 - 13,000 singing ♂ at 12 sites, but more than 95 % of the population are concentrated in six large fen mire tracts. The major habitat factors affecting population density were identified (Tab. 2 & 3). The Aquatic Warbler is a true stenotopic species preferring exclusively particular fen mire types which are characterised by mesotrophic to poor eutrophic level, constant water table near the soil surface, medium vegetation height and density, and high coverage of the mire surface by green mosses. Many or most of Aquatic Warbler pairs seem to produce two broods within the breeding saison, but fluctuations in numbers and movements between different sites within one breeding saison are frequent, depending on water table changes (Tab. 8). The density is also affected by burning: after spring fires the density drops to a minimum level and is restored completely only two years after fire (Tab. 7). We estimate from retrospective balance of fen mire areas, that the population size of Aquatic Warbler must have suffered a decline by more than 90 % within the last 30 years. Other factors threatening the species are changes in water regime, water pollution and eutrophication, overgrazing, early hay-cutting, unsuitable methods of spring burning, and vegetation succession (overgrowing with shrubs or reeds) due to abandonment of hydrologically altered fen mires. Finally, consequences for conservation and research are summarised (chapter 6).

Key words: Aquatic Warbler *Acrocephalus paludicola*, globally threatened species, fen mires, habitat requirements, species conservation, Belarus.

1. Introduction

As the AQUATIC WARBLER CONSERVATION TEAM (1999) has pointed out, the remaining population of Aquatic Warbler is highly vulnerable due to its concentration in only a few large mire tracts. The three river mire systems of upper Pripyat, Yaselda and Biebrza hold about 80 % of the known world population, and more than the half of the entire population is concentrated in the south-west of Belarus. When the Belarusian population was discovered in 1995-1997, a strong decline due to mire destruction by drainage and abandonment was still in progress. On the other hand, the links and interactions between drainage measures and other alterations of the water regime, low-intensity agricultural use, trophic level of the mires and vegetation succession, as well as the impact of these factors on density and breeding success of the Aquatic Warbler were still poorly understood. Nevertheless, ecological research on Aquatic Warbler in Central and Eastern Europe made great progress since 1996. The Michael Otto Foundation, a private German foundation for environmental protection, funded projects in Belarus to prepare an inventory of remaining sedge fen mires and Aquatic Warbler populations, to implement a fen mire monitoring system and to develop a conservation strategy for the Belarusian Pripyat floodplain. These projects have been initiated and co-ordinated by M. FLADE (Germany) and conducted in Belarus by A. KOZULIN. Recently, the British Darwin Initiative has decided to fund the preparation of management plans for the major Belarusian fen mires as well as the concomitant research which is necessary to implement those plans.

In Belarus, nearly all potential Aquatic Warbler sites have been investigated by scientist from the National Academy of Sciences, and studies on popula-

tion development, habitat structure, breeding success and diet of the species were initiated. This paper summarises some important results of the first three years of surveys and research.

2. Methods

In preparation for searches of Aquatic Warbler habitats, we studied various published and unpublished material on the open fen mire distribution in Belarus. The vegetation map in the monograph of YURKEVICH *et al.* (1979), which illustrates the fen mire distribution in 1977, was one of the main sources. The use of these data and recent fine-scale topographic maps allowed us to determine the distribution of the largest intact fen mire tracts.

The main fieldwork was carried out from May 15 to August 20 of the years 1996-98. Aquatic Warbler censuses were done using a transect method from 60 minutes before until 45 minutes after sunset ("sunset counts"), when singing activity of ♂ reaches its daily peak. Singing ♂ were counted within a 200 m belt (100 m to the left, 100 m to the right). Length of the transects was between 1.0 and 1.8 km per observer and evening. Since usually 3-5 observers worked together, the size of surveyed plots was 1.0-1.5 km^2 per evening. The transects were chosen after a preliminary mire survey and the most characteristic parts of the mire were represented. Estimates of total population size were then possible by combining density values and estimates of habitat area by analysing maps and aerial photographs. - Other fen mire bird species were censuses simultaneously. Because evening censuses do not yield reliable densities of most of the breeding bird species, we used four ranks for the classification of density, from abundant to rare.

Mire descriptions were carried out, also using a transect method, and transects were walked from the edges to the centre of the mire tract. By describing the grassy vegetation, the main attention was devoted to the dominant associations and co-dominant species. Most of the plant species were identified at the Institute of Experimental Botany, Belarusian Academy of Sciences, Minsk. We used published data of floristic surveys carried out in the Polesia fen mires, sometimes at the same mire tracts were we worked (YURKEVICH 1973, 1975; PARFENOV *et al.* 1973; PARFENOV & KIM 1976; RYKOVSKY 1980), for more complete descriptions of grass and moss vegetation, vegetation cover and various ecological factors at the Aquatic Warbler habitats.

Total mire area and area of habitat suitable for Aquatic Warbler was calculated from geographical maps (scale 1 : 50,000). Aerial photographs (1: 20,000) were used for calculation of the area covered by shrubs, dry islands within the mire and open parts of the mire. Data on some additional ecological factors (i.e. level of ground water table and its summer time changes, height of the main vegetation layer and area occupied by tussocks) were also collected during the mire surveys.

In 1998, monitoring plots of 40-120 ha were established in the five most important Aquatic Warbler breeding areas of Belarus. During May-July 1998, three surveys (May 21-29; June 22-26; July 20-25) of the density of singing ♂ were conducted (Tab. 2 & 8). Plots were divided into rectangles of 100 x 200 m and birds were recorded on transects 1 - 1.5 km long (sunset counts, see above). For studying the nesting phenology and breeding success, we searched for nests and counted ♀ giving alarm calls, indicating they had fledglings. The incubation stage of clutches was determined using the water test, the age of nestlings was estimated from plumage development; fledglings were assumed to be 20 days old. In total 18 nests and 15 ♀ with fledglings were found in 1998.

The following environmental and habitat factors, which are believed to be important determinants of density and timing of nesting were taken into account and recorded on the monitoring plots:

- water level above soil surface
- character of the mire relief
- pH value
- oxygen content
- level of water mineralisation
- species composition of insects
- species composition of the hydrobios
- proportion (in %) of the vegetation associations
- height and structure of vegetation
- time period after the last fire.

3. Study area

All studies were conducted in the Belarusian Polessie region. Northern parts of Polessie (Belarusian Polessie) are situated in Brest, Gomel and Minsk regions of Belarus, and southern parts occupy four North-Ukrainian regions: Kiev, Rivne, Volyn and Zhitomir. Total area of Polessie covers 131,920 km^2, 60,980 km^2 in Belarus and 70,940 km^2 in the Ukraine (DEMENTIEV *et al.* 1977). The relief of Polessie was formed by the Dniepr and Sozh glaciers and their melting waters. Polessie is characterised by flat relief, shallow surface inclination and high level of ground water table. Altitudes above sea level vary from 100 to 150 m. These conditions as well as a rather high amount of precipitation (600 mm/year) and suitable temperature regime led to the development of wetlands (MARTSINKEVICH *et al.* 1972). Huge wetland areas are represented mainly by fen mires with peat sediments of low thickness (1.1-1.8 m). In 1960, the total area of open sedge fen mires was ca. 3,800 km^2, but decreased to currently about 444 km^2 (of which 154 km^2 of sedge fen are classified as suitable for the Aquatic Warbler, see below) as a result of wide-scale wetland drainage campaigns.

Twelve recent Aquatic Warbler breeding sites were found in Belarus, five of them are large mire tracts with 420-7,000 singing ♂ each. These mire tracts are described in detail below. The most important Aquatic Warbler breeding sites were found in the Brest region and are represented by large fen mire tracts (20-190 km^2) situated in river floodplains (Pripyat and Yaselda Rivers) as well as at watersheds. The four major Aquatic Warbler breeding sites represent large tracts of open sedge fen with various trophic levels. They can be ranked in the following ascending order (from poor mesotrophic to eutrophic): Dikoe, Sporova, Zvanets, Yaselda S Berioza (see Tab.1, 2).

1. The **Dikoe mire** tract (Fig. 2 & 3) is situated on the Yaselda-Narew rivers watershed, its northern and western borders coincide with the border of the Belaveshkaya Pushcha National Park. It is a transitory mire, between a

typical fen and an oligotrophic mire. The eastern central part resembles a raised bog, the other more western and southern parts consist of mesotrophic fen mire. Environmental conditions are extremely stable. The mire is practically not used for hay-making, therefore there were no fires during the last decade, although fires were quite common earlier (according to local people). The mire contains the springs of Yaselda and Narew rivers, but no rivers flow into it. The mire is exclusively fed by ground water and precipitation. This guarantees a stable water level, which fluctuates from 1 to 5-10 cm in May-July nearly regardless of the amount of local precipitation.

Total mire tract area is ca. 8,100 ha, the mesotrophic sedge fen occupies 2,400 ha, the remainder represents poor mesotrophic fen and transitory bogs, shrubs and forest islands. Vegetation of the sedge fen part of the mire is a mixture of numerous plant associations. Associations with dominance of *Carex lasiocarpa, C. rostrata, C. diandra* and *Calamagrostis neglecta* are most common. Soil cover consists of mosaic complexes of true mosses (*Scorpidium scorpioides, Meesea triquetra, Calliergon giganteum, Drepanocladus vernicosus* and some other species; PIDOPLICHKO 1961). Mean thickness of peat sediments is 1.41 m, maximum up to 3 m. The upper layer of peat sediment is formed by sedge and sedge-*Hypnum* peat and has a floating surface (water-saturated moss pillow), which is 30-40 cm thick and has been lifted off from the base peat sediment. The valley bottom is covered by well-defined mass of wood-reed, wood and rarely wood-sedge peat (PIDOPLICHKO 1961).

Water source of the mire is mainly from the ground, the water table is nearly constant and is maintained at the level of soil surface. In the eastern part of the tract ground water table decreased significantly due to the drainage in this part of the mire and the adjacent upper Yaselda valley in the east. Five channels were dug through the mire in the course of drainage work in the 1940^{ies}, which are now almost completely overgrown by mire vegetation.

A high density of Aquatic Warbler (62 ♂/km^2) was recorded only in the western part of the mire tract which may be classified as sedge-*Hypnum* mire with poor feeding, with no more than 5% occupied by shrubs. Occurrence of *Sphagnum* mosses in the soil cover increases toward the east, the opposite trend was recorded for Aquatic Warbler, its density decreasing to 7 singing ♂/km^2 towards the central part of the mire. The eastern part of the tract is an oligotrophic bog, and Aquatic Warbler was not recorded there.

2. The **Sporova mire** (Fig. 4) is situated in the Yaselda river floodplain, in an area adjacent to Lake Sporovskoye (Berioza and Drogichin districts). Total mire area is 2,400 ha, a considerable part of which (ca. 25%) is covered now by shrubs as a result of changes in water regime after draining ca. 50 % of the surrounding area. The structure of the mire is highly patchy and mosaic-like: typical eutrophic tracts overgrown by willow shrubs alternate with mesotrophic open tracts. Numerous mineral islands are scattered over the area. In March - early May the mire is inundated during the spring flood, with a water depth of 15-30 cm. The water level in the study plot in 1998 dropped from 10 cm in late May to 0 cm in early July. Preservation of a relatively stable water level is explained apparently by the presence of a large lake (1,000 ha), which accumulates water during summer floods. Spring burning of grass in the mire is quite infrequent (once every 3 years on average) and is performed on small plots only.

Riparian plant associations play a dominant role in the vegetation cover reflecting the dominance of more or less running-water conditions. Large areas are covered by *Glyceria maxima*, considerable reedbeds are situated along the river. Mire parts with prevalence of stagnant moisture occur on ca. 1,000 ha, vegetation there consists of *Carex elata, C. rostrata, C. appropinquata, Molinia caerulea, Carex panicea* and *C. diandra* associations. Peat sediment thickness is 1.5-2.0 m, ground water table from mid May to August varies between +10 and -5 cm. There was practically no hay cutting in recent years. A considerable part of the mire was declared a nature reserve of national importance in 1978.

Aquatic Warbler was found only in patches with stagnant water. Such patches occur throughout the whole tract with some concentrations in pre-mainland parts. A considerable part of the mire with high Aquatic Warbler density is situated to the north-east of Kokoritsa.

3. The **Zvanets mire** (Fig. 5) is situated in Drogichin and Kobrin Districts of Brest region, south of Dniepr-Bug Channel. It is the largest remaining fen mire tract in Belarus and probably in the whole of Europe, its total area is ca. 190 km^2. The relief of the mire is typical for Brest Polessie with an alteration of large flattened depressions and numerous mineral islands dispersed chaotically within the huge mire lowland. Island size varies from several tens to several hundreds of meters in diameter, their mean height above the mire level is 1 m. Most of the peat sediments is shallow, 0.3-1.0 m thick (PIDOPLICHKO 1961). The hydrological conditions of the mire are influenced by two large canals connecting the Dniepr-Bug Channel with the Pripyat. Along the periphery of the mire a large drainage canal is located; water in the canal is regulated at a pump station according to the condition of the surrounding drained areas. Water level in the mire over the period May-July fluctuates from -10 to +40 cm depending on the amount of precipitation and water level in the Pripyat. However, the peculiarities of the relief guarantee some non-inundated areas on the mineral islands even during strong floods. The islands are then ploughed or cut by local people, a part of the mire is also used for hay-making. It is the major reason for regular spring burning of mire vegetation (once every two-three years on average). In exceptionally dry years, when water level drops to -20 cm, huge fires can occur resulting in burning out of the upper peat layer (this last happened in 1988).

Sandy elevations total about 20% of the area, the rest is covered with mire grass vegetation with *Carex elata, C. omskiana, C. appropinquata* and *Calamagrostis neglecta* associations dominating. In the upper layer of practically all formations *Phragmites australis* occurs with small coverage (5-20 %), but in some mire parts with high water table it forms also dense reedbeds. In 1993 ca. 40 % of mire tract area were declared a nature reserve (zakaznik) of national importance. The only economic use of the mire is by hand-cutting for hay-making on no more than 20 % of total area. The southern part of the mire (S

Fig. 1: Female Aquatic Warbler carrying food for nestlings; Yaselda mire S Berioza, summer 1998. – *Futtertragendes Seggenrohrsänger-♀ im Yaselda-Talmoor S Beriosa, Sommer 1998.*
Photo: A. KOZULIN.

Fig. 4: Large tract of intact fen mire near lake Sporova, NE of the village Kokoritsa. – *Großer Seggenmoorkomplex nahe des Sporova-Sees nördöstlich des Dorfes Kokoritsa, Anfang Juni 1996.*
Photo: M. FLADE, early June 1996.

Fig. 2: Mesotrophic sedge-*Hypnum* fen with fructificating Cotton Grass *Eriophorum angustifolium (= polystachion)* in the western part of Dikoe near the Narew spring. – *Mesotrophes Braunmoos-Seggenmoor mit fruktifizierendem Schmalblättrigem Wollgras im Westteil von Dikoe; hier entspringt die Narew; Anfang Juni 1996.*
Photo: M. FLADE, early June 1996.

Fig. 5: The huge fen mire tract of Zvanets (190 km^2) is likely to be the largest intact sedge fen mire in Europe; beside the sedge cover (*Carex appropinquata* dominating) of about 60-70 cm height the scattered, weak and low stems of Common Reed *Phragmites australis* are typical; in the foreground flowering *Pedicularis palustris*. – *Die riesige Moorfläche Zvanets (190 km^2) ist wahrscheinlich das größte intakte Seggenmoor Europas; neben der kniehohen Seggenschicht (dominierend hier Schwarzschopfsegge* Carex appropinquata*) sind die sehr licht stehenden, niedrigen und schmächtigen Schilfhalme* Phragmites australis *typisch; im Vordergrund blühendes Sumpf-Läusekraut* Pedicularis palustris *(Mitte August 1996).*
Photo: M. FLADE, mid-August 1996.

Fig. 3: In many parts of the fen of W-Dikoe coverage of sedges is relatively low; around the tufts of *Carex omskiana* typical fen mire plants like *Lysimachia thyrsiflora* (yellow flowers), *Comarum palustre* (red) and *Menyanthes trifoliata* (broad leaves) can be seen. – *In vielen Teilen des Seggenmoores in W-Dikoe ist der Deckungsgrad von Seggen relativ gering; rings um die lockeren Büschel von* Carex omskiana *sind typische Niedermoorpflanzen wie Strauß-Gilbweiderich* Lysimachia thyrsiflora *(gelbe Blüten), Sumpf-Blutauge* Comarum palustre *(rot) sowie die breiten Blätter des Fieberklees* Menyanthes trifoliata *zu erkennen.*
Photo: M. FLADE, early June 1996.

Fig. 6: Sedge-*Hypnum* fen with scattered low willow shrubs are characteristic for the parts of Yaselda floodplain mire with maximum density of Aquatic Warbler (35 singing ♂/10 ha); near Peschanka S Berioza, early June 1996. – *Braunmoos-Seggenmoor mit eingestreuten niedrigen Weidenbüschen ist die charakteristische Struktur auf den Teilflächen des Jaselda-Talmoores mit den höchsten Seggenrohrsänger-Dichten (35 sing. ♂/10 ha); bei Pestschanka S Beriosa, Anfang Juni 1996.* Photo: M. FLADE.

Fig. 7: Female Aquatic Warbler with food near the nest, Yaselda fen mire S Berioza, summer 1998. – *Seggenrohrsänger-♀ mit Futter nahe des Nests im Jaselda-Talmoor S Beriosa im Sommer 1998.* Photo: A. KOZULIN.

Fig. 8: Aquatic Warbler nest with 5 nestlings in the Yaselda fen mire S Berioza; breeding success in the Yaselda fen is very high, so far no floodings or late burning are destroying the broods. – *Seggenrohrsänger-Brut mit 5 Nestlingen im Jaselda-Talmoor S Beriosa; der Bruterfolg im Jaselda-Talmoor ist sehr hoch, sofern die Bruten nicht durch niederschlagsbedingte Hochwasser oder späte Brände zerstört werden.* Photo: M. FLADE, June 1998.

Fig. 9: This Aquatic Warbler brood with nearly fledged young at lake Sporova survived the cutting of the sedge meadow by hand scything and was successful. – *Diese Seggenrohrsänger-Brut mit fast flüggen Jungvögeln am Sporova-See überstand die Mahd der Seggenwiese mit der Sense und verlief erfolgreich (Juli 1996).* Photo: A. KOZULIN, July 1996.

Fig. 10: Excavation of sun-dried peat of a former large sedge-*Hypnum* fen in the mid-Yaselda region near Chomsk in August 1996. – *Abbau von sonnengetrocknetem Torf eines ehemaligen großen Braunmoos-Seggenmoores mit Exkavatoren im mittleren Jaselda-Gebiet bei Chomsk im August 1996.* Photo: M. FLADE.

of the nature reserve) has been drained in the 1990ies, drainage work was still ongoing in 1995.

Aquatic Warbler censuses were carried out in the southern (environment of Povitie) and western (east of Chabovichi) parts of the remaining mire tract. The density is highest in the parts with negligible occurrence of reeds and decreases with growth of reeds. Aquatic Warbler was absent in the parts where dead reed stems covered more than 50 % of total area. In the extreme western part of the mire suitable Aquatic Warbler habitats occur as small (10 and somewhat more ha) patches among unsuitable area covered with reed and low birch *Betula pubescens* thickets.

4. The **Yaselda river floodplain** between Berioza and Chomsk takes the form of a more or less narrow stripe along the river. The length of floodplain stretch is 25 km, its width is between 1 and 3 km, total area of swampy floodplain and adjacent mires is ca. 2,500 ha. The river bed is subject to intensive overgrowing; in some parts it becomes vague. The floodplain is very flat, barely rising above the mid-summer river level and so is easily flooded by a 20-50 cm rise of water level of the river. Any elevations of the relief are absent; tussocks are unobtrusive. Poor channel permeability of Yaselda river and flatness of the relief are major causes of quick and long-lasting inundation of the floodplain even after little precipitation. Spring flooding on Yaselda occurs usually from early March to the second half of May, its mean duration is 75 days, maximum up to 150 days. During the spring flooding river water table exceeds mid-summer level by 1-1.5 m, and depth of the flooding in the floodplain is 0.5-1 m (PARFENOV *et al.* 1973).

When the water level increases by 30-40 cm, all places suitable for Aquatic Warbler nesting are inundated. Summer floods were observed in early July 1997 and 1998. Such floods can also be caused by water management of the big Selets fish farm (2,500 ha), which is situated upstream of the mire. – Usually, water level remains high well into September. Mean depth of peat sediment is 1.7 m, its upper layer consists of sedge and sedge-*Hypnum* peat. Significant parts of the mire are used for hay-making, therefore certain areas are subject to frequent burning. Vegetation in the floodplain changes according to the distance from the riverbed. *Carex acuta* and *C. vesicaria* formations dominate in the more wet and running-water parts, and *C. elata, C. rostrata* and *C. diandra* formations dominate in pre-mainland parts. From May to August ground water table in the pre-mainland part of the mire varies between 0 and 10 cm. Agricultural use of the floodplain consists of hand-cutting for hay-making in a 50-150 m stretch along the outer floodplain border.

The most detailed Aquatic Warbler censuses were carried out near the villages Peschanka and Kostyuki in 1996-1998. Aquatic Warblers are unevenly distributed in the floodplain, the highest density (135 ♂/km^2, in smaller areas up to 36 ♂/10 ha) was recorded along the outer edges of the floodplain mire. Warbler density decreases gradually towards the riverbed where the mire is wetter and the vegetation is taller. Large parts of the sedge mire area were burned in April 1997. Aquatic Warbler was practically absent in the burned areas (9-15 ♂/km^2).

5. The **Low Yaselda mire** is situated near **Yaselda mouth**, between Yaselda and Pripyat (Pinsk district). Total mire area is ca. 2,000 ha. The mire is situated in a network of shallow depressions of the Pripyat floodplain and was formed under the joint impact of two factors, mire formation and alluvial-diluvial processes. Open sedge fen mires cover ca. 700 ha, the rest of the tract is represented by open sandy elevations and shrubs. Peat sediments are shallow (30-60 cm thickness) and consist mainly of grass-sedge peat. The vegetation is typical for herb-sedge-grass floodplain mires. In running-water parts with large water table fluctuations *Glyceria maxima, Phragmites australis* and *Carex acuta* associations dominate, *C. elata, C. omskiana, C. appropinquata* and *C. rostrata* associations are most common in the stagnant parts. The whole mire is covered by spring flooding up to mid-May, water table during this period is +30-50 cm. In June-August soil water table level drops to -30-50 cm. Ca. 20 % of the area is used for hay-making and cattle grazing. The whole tract is protected as a nature reserve. Aquatic Warbler is unevenly distributed according to the distribution of patches with stagnant moisture.

6. The **Prostyr mire** is situated between the Pripyat and Prostyr rivers in Stolin district. Total mire area is ca. 3,000 ha, the main habitats are fen mires, herb-sedge meadows and sandy islands. Peat sediments are shallow, with 30-60 cm thickness. Spring flooding covers the mire up to mid or late May, in June water table varies between 30 and 60 cm in different parts of the tract. *Phragmites australis, Glyceria maxima* and *Carex acuta* associations predominate in wetter places, places with predominantly stagnant moisture and constant water table are occupied mainly by *C. omskiana* and *C. rostrata* associations.

4. Results and Discussion

During 1995-98 we studied 23 localities where breeding of Aquatic Warbler was regarded to be possible. Breeding birds were recorded at 12 localities, their total number was estimated at 7,300-13,000 singing ♂. Most of the population was concentrated in six large fen mire tracts (Dikoe, Yaselda-Berioza, Yaselda-Sporova, Zvanets, Yaselda mouth and Low Prostyr) with 160-7,600 singing ♂ in each. Any of the six remaining localities supported less than 100 ♂. Total area of fen mires suitable for Aquatic Warbler breeding in Belarus is ca. 15,400 ha. Data on sizes of the areas and their respective Aquatic Warbler populations are given in Table 1. The most important Aquatic Warbler breeding localities were found in Brest region and are represented by large fen mire tracts (20-190 km^2), situated in river floodplains (Pripyat, Yaselda, Styr) as well as at a watershed (Dikoe).

4.1. Habitat factors affecting Aquatic Warbler density

During the mire surveys, some environmental factors which may directly or indirectly affect habitat suitability for Aquatic Warbler were described (Table 2).

Preliminary study allowed us to calculate correlations (SPEARMAN's rank r_s) between Aquatic Warbler density and environmental factors. Breeding density of Aquatic Warbler is affected to a considerable extent by the size of the suitable habitat patch. Populations with high density were found only in the large mire tracts with an area of more than 5-10 km². High density in small mires (less than 1 km²) was recorded only in mires situated closely to large ones, e.g. near Chabovichi in a small mire tract 5 km from the huge Zvanets mire. A few singing ♂, not more than 10 per site, were counted in small mires far from large populations (e.g. in Braginka, Shchara and Svisloch floodplains, Bobrovichskoe Lake). Low density in the small habitat patches may be the consequence of the species' need for large open mire tracts lacking tall shrubs. Probably Aquatic Warbler does not occupy small mires due to the proximity of ecotones with a high density of Sedge Warbler. Another reason could be the extraordinary breeding system with a high degree of promiscuity (summarised by SCHULZE-HAGEN *et al.* 1999, this issue), for which a high concentration of birds should be advantageous.

Table 1: Results of the Aquatic Warbler survey in Belarus, 1996 -1998; density values are derived from study plot sunset counts; minimum and maximum densities describe variations in different subareas and/or between years. – *Ergebnisse der Seggenrohrsänger-Bestandserfassung in Belarus 1996-1998; die Dichtewerte wurden mittels Zählungen während des Sonnenuntergangs auf Probeflächen ermittelt, die Schwankungsbreite beschreibt Unterschiede zwischen verschiedenen Teilflächen und/oder verschiedenen Jahren.*

site	total open fen mire area in km²	suitable habitat area in km²	density, ♂/km² (plots)	population estimate
Dikoe	81	24	(7 -) 50 - 62	1,700 - 1,800
Yaselda S Berioza	25	16.5	25 - 135	940 - 1,550
Yaselda - Sporova	24	10	30 - 40	420 - 570
Zvanets	190	80	45 - 95	3,600 - 7,600
Yaselda mouth	20	10	15	120 - 160
Lower Prostyr	30	10	23	450 - 900
6 other sites	74	6.4	*no data*	60 - 450
Total:	**444**	**154**	**25 - 135**	**7,290 - 13,030**

One of the main factors affecting Aquatic Warbler density is the mire water regime, which determines several other habitat features. Water table changes during the period from May to August or the water table level prior to the breeding period may be used as water regime indices. As field data suggest, high density was observed only in the mires with rather constant water table, where its fluctuations did not exceed 20 cm. Optimal conditions for the species exist in mires with water level just at the soil surface (e.g. a water-saturated layer of green mosses). On the contrary, low densities were recorded in mires where spring water table was 0.5 m above the surface and in mid summer the ground water receeded 0.2-0.5 m below ground surface.

Table 2: Some important habitat characteristics of mires, where breeding of Aquatic Warbler was recorded or suspected in Belarus; all data are from 1996. – *Einige wichtige Habitatparameter von Mooren, in denen ein Brutvorkommen des Seggenrohrsängers festgestellt oder (anfangs) vermutet wurde; alle Daten stammen aus dem Jahr 1996.*

locality	Aquatic Warbler density (♂/km²)	total area of suitable habitat (km²)	water table fluctuation (cm) May - August	May water table (cm)	average sedge hight (cm)	coverage of tussocks (%)	coverage of green mosses (%)
Yaselda-Berioza	135	16,5	10	5	70	50	90
Dikoe	62	24	0	0	60	40	100
Zvanets	45	80	10	10	60	80	60
Sporova	30	10	15	10	60	100	60
Prostyr	23	10	90	30	110	70	5
Yaselda mouth	15	7	60	20	100	60	5
Bobrovichi	10	0.5	20	10	60	80	5
Svisloch	10	0.5	80	20	110	50	2
Styr	5	10	100	30	100	30	1
Shchara 1	1	0.3	80	40	100	50	0
Shchara 2	0	1	80	40	120	0	0
Sozh	0	1	100	50	130	0	0
Berezina	0	0.5	110	40	120	10	2
Shchara 3	0	0.5	130	50	110	100	1
Yaselda 3	0	0.5	60	20	100	50	1
Ptich	0	0.3	120	50	130	80	0

Fig. 11: Peat briquettes from sedge fen peat have a quality similar to brown coal briquettes; Starobin near Saligorsk, August 1996. – *Briketts aus Seggenmoortorf haben eine ähnliche Qualität wie Braunkohle-Briketts; Torffabrik Starobin bei Saligorsk, August 1996.* Photo: M. FLADE.

Fig. 12: Corn crops on a recently drained former sedge fen mire N of lake Sporova, early June 1996. – *Maisacker auf einem vor kurzem meliorierten ehemaligen Seggenmoor nördlich des Sporova-Sees, Anfang Juni 1996.* Photo: M. FLADE.

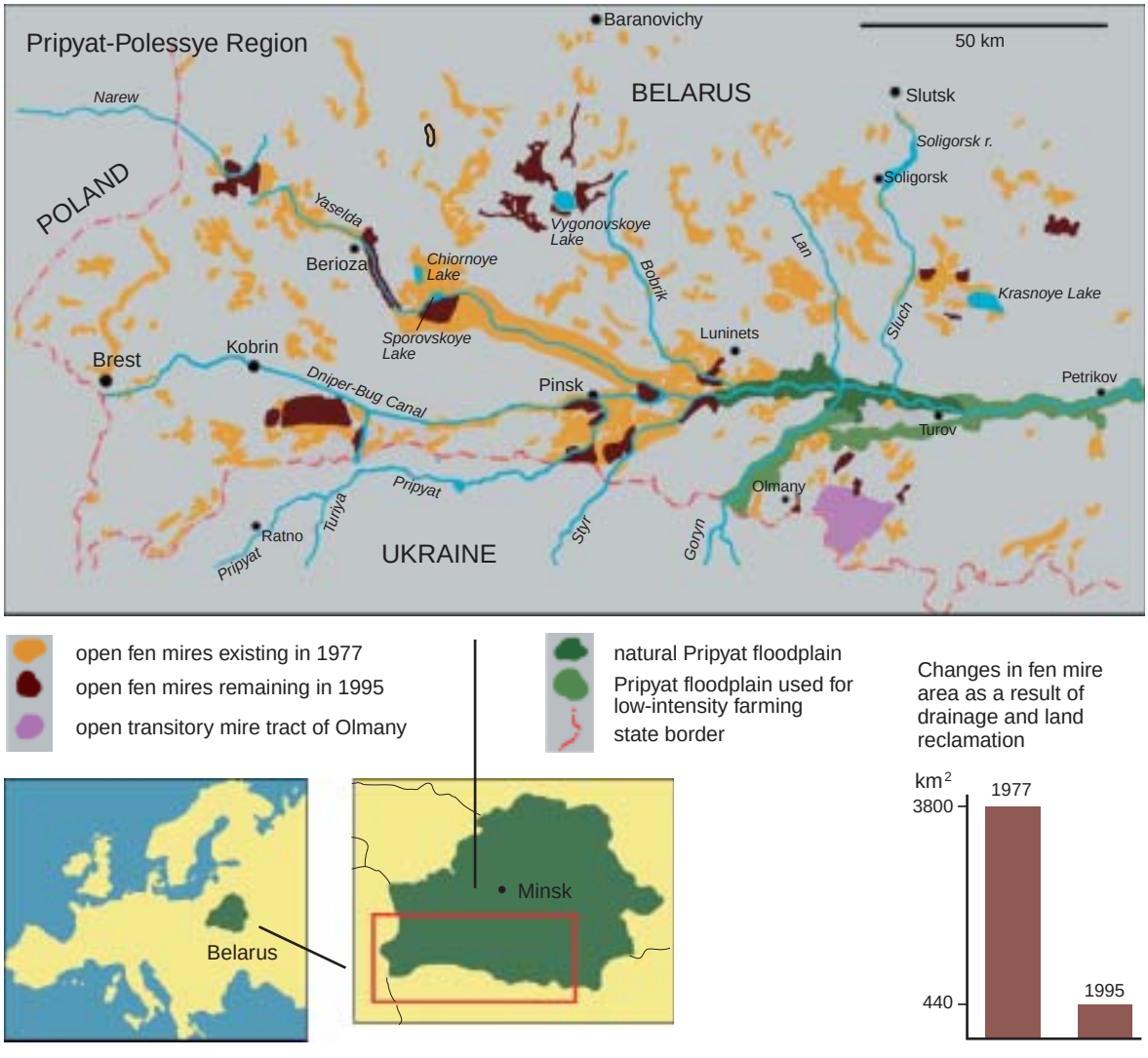

Fig. 13: Map of recent fen mires in Southwest-Belarus and fen mires drained and transformed since the early 1970ies. – *Karte der heute noch erhaltenen und der seit den frühen 1970er Jahren meliorierten Niedermoore in SW-Belarus.*

The height of the main vegetation layer, represented usually by various *Carex* species, also affects the density, probably through its effect on food availability. Aquatic Warbler reaches considerably higher densities in habitats where sedge height does not exceed 1 m (optimum 60-70 cm). It seems that the vegetation thickness (horizontal density) plays an important role as well: the species tends to prefer medium sedge density and avoids places with tall and very thick vegetation. A correlation analysis shows that occurrence of tussocks and their abundance in the mire does not affect Aquatic Warbler density. Density did not differ between mires with ca. 40% and those with more than 80% tussock cover.

The proportion of the mire surface covered by green mosses is one of the most important indicators of suitability for Aquatic Warbler. The highest density of the species was observed in sedge-*Hypnum* mires where green mosses cover 90 - 100% of the surface. Changes of the mire trophic level in both directions result in a decrease of Aquatic Warbler density. On the one hand, oligotrophic or poor mesotrophic mires with occurrence of *Sphagnum* mosses obviously are unsuitable for the warbler. Increase of the trophic level from the (mesotrophic to poorly eutrophic) optimum leads to decrease both in green moss cover and Aquatic Warbler density, both being lowest in the floodplain associations with high flooding and unstable, periodically insufficient moisture conditions (RYKOVSKY 1980).

Table 3: Correlations (SPEARMAN's rank r_s) between Aquatic Warbler breeding density and some habitat parameters in Belarus (n = 16; * = p < 0.05). – *Korrelationen (SPEARMANs Rangkorrelation) zwischen Seggenrohrsänger-Dichte und Habitatparametern in Belarus (n = 16; * = p < 0,05).*

habitat parameter	Spearman's rank r_s and significance
area size of suitable habitat	0.52 *
water table fluctuation	-0.74 *
May water table	-0.73 *
sedge height	-0.68 *
coverage of tussocks	0.16 n.s.
coverage of green mosses	0.92 *

4.2. Classification of Aquatic Warbler habitats

Analysis of the data collected allows us to classify the main Aquatic Warbler breeding habitats in Belarus on the basis of cluster analysis of Aquatic Warbler density and some habitat parameters. All localities studied can be divided by cluster analysis into two groups: herb-sedge-grass and sedge-*Hypnum* mires (YURKEVICH *et al.* 1979) or, using a recent classification developed for Belarus (preliminary prodromus of I. STEPANOVICH, pers. comm.), mire-grass communities and lowland grass mire communities.

The surveyed mire-grass communities (herb-sedge-grass mires) are concentrated mainly in the floodplains of the Pripyat and its tributaries (Styr, Yaselda) and of the Shchara river. This mire type develops over shallow grass-sedge and *Hypnum*-grass-sedge peat sediments (30-60 cm, up to 120 cm; PIDOPLICHKO 1961). Formation of this mires in the floodplains results from the interrelation of two processes: mire formation due to constant water excess and alluvial-diluvial processes. A large volume of mineral and silt particles was accumulated under the influence of alluvial-diluvial processes resulting in a long-lasting maintenance of the eutrophic character of these mires. Aquatic Warblers inhabit only vegetation associations growing in conditions of very little running water and with a water table of 0-30 cm in late spring.

Such mires are situated in shallow floodplain depressions which are not reached by high floods, and pre-terrace parts (Low Yaselda, Styr, Prostyr). Density of Aquatic Warbler in the floodplain mires is much lower than in watershed mires (cluster no. 2 in Tab. 4). The ratio of Aquatic Warbler to Sedge Warbler *Acrocephalus schoenobaenus* is ca 1:10 in the mires of this group.

Lowland grass mires (sedge-*Hypnum* mires) with poor feeding occupy flat watersheds and over-floodplain terraces. This kind of mires has remained mainly in the Brest region, but prior to the wide-scale drainage it prevailed in the whole Belarusian Polessie. These mires are characterised by poor or no run-

Table 4: A statistical cluster analysis showed that the studied mires form two clearly separated groups; the table shows Aquatic Warbler density and habitat characteristics of the two groups. – *Eine Clusteranalyse ergab, daß die untersuchten Seggenmoore zwei deutlich verschiedene Gruppen bilden; die Tabelle zeigt Seggenrohrsänger-Dichte und Habitatcharakteristika dieser beiden Gruppen auf.*

statistical cluster analysis variable	cluster means (n = 16)	
	cluster no. 1	cluster no. 2
density of Aquatic Warbler (singing ♂/km²)	49.4	4.9
suitable habitat area (km²)	26.2	3.1
water table fluctuation May - August (cm)	11.0	91.8
May water table (cm)	7.0	35.5
sedge height (cm)	62.0	111.8
coverage of tussocks (%)	70	45.5
coverage of green mosses (%)	63	1.5

cluster no. 1: Dikoe; Yaselda-Berioza; Zvanets; Sporova; Bobrovichskoe.
cluster no. 2: Yaselda mouth; Prostyr; Styr; Svisloch; ... (11 mires in total)

ning-water conditions and the absence of plant species which need good soil aeration. Such species are substituted by *Hypnum* mosses which may dominate in the later succession stages. In Polessie sedge-*Hypnum* mires occur in huge shallow depressions. Close proximity of the ground water table (usually near or at the soil surface) determined the eutrophic conditions of mire formation. Peat deposits are usually rather thick (1.5-2 m) and consist of sedge-*Hypnum* peat (PIDOPLICHKO 1961). Associations of *C. elata C. diandra, C. rostrata* and *C. appropinquata* are most common. Five of the studied mire tracts (Yaselda-Berioza, Dikoe, Zvanets, Sporova, Bobrovichskoe) belong to this type. Aquatic Warbler reaches the highest breeding density in the mires of this type (cluster no. 1 in Tab. 4). The ratio between the numbers of Aquatic and Sedge Warblers varied between 1:1 (Zvanets after fire, Sporova) and 30:1 (Dikoe).

Based on our results we conclude, that the Aquatic Warbler is a true stenotopic species occupying only particular fen mire types. The best conditions for the species exist in fen mires with poor feeding and mesotrophic level, with *Hypnum* mosses dominating in the moss cover. Aquatic Warbler density decreases when the mire trophic level changes in both directions from the described: it does not breed in oligotrophic mires and even avoids to breed in *Sphagnum*-dominated patches of mesotrophic or eutrophic mires, but low densities are also observed in mires with high trophic level: a decrease of the surface proportion covered by true mosses and an increase of Sedge Warbler density can be regarded as indicators of an increase in mire trophic level.

Table 5: Prodromus of plant associations which characterise the Aquatic Warbler habitats of Belarus (according to the international syntax system). – *Prodromus von Pflanzengesellschaften, die die Habitate des Seggenrohrsängers in Belarus charakterisieren.*

Class 7. Molinio-Juncetea (effusi)
(wet meadow communities)
Vord 1. Molinietalia
Union 2. Molinion (caeruleae)
Assoc. 1. Molinetum caeruleae

Class 9. Phragmitetea (australis)
(mire-grass communities)
Vord 2. Phragmitetalia
Union 2. Caricion rostratae
Assoc. 1. Caricetum omskianae
Assoc. 2. Caricetum appropinquatae
Assoc. 3. Caricetum rostratae

Class 10. Scheuchzerio-Caricetae fuscae
(lowland grass mire communities)
Vord 2. Scheuchzerietalia palustris
Union 1. Caricion elatae
Assoc. 1. Caricetum elatae
Assoc. 2. Caricetum diandrae
Assoc. 3. Calamagrostidetum neglectae
Assoc. 4. Caricetum juncellae
Union 2. Caricion lasiocarpae
Assoc. Caricetum lasiocarpae

4.3. Vegetation composition of Aquatic Warbler habitats

Aquatic Warbler habitats consist mainly of the following vegetation associations: Caricetum diandrae, Caricetum rostratae, Caricetum elatae, Caricetum omskianae, Caricetum juncellae, Caricetum appropinquatae, Calamagrostidetum neglectae and Caricetum lasiocarpae (see Table 5). In all other associations of Phragmitetea (australis) and Molinio-Juncetea (effusi) classes only single Aquatic Warblers may breed or sing occasionally. *Carex elata* associations are widely distributed in all large mires excluding Dikoe, where this sedge species occurs only on very small areas. The dominant species grows well under high running-water conditions and soil moisture. Co-dominants in *Carex elata* associations are *Calamagrostis neglecta, Galium palustre, Caltha palustris, Equisetum fluviatile, Comarum palustre* and *Menyanthes trifoliata* (YURKEVICH *et al.* 1975).

Carex rostrata associations are typical for mire patches with very high soil moisture where water table level coincides with soil surface, and micro- and nanorelief are practically absent. Co-dominants in *Carex rostrata* associations are *Agrostis stolonifera, Caltha palustris, Comarum palustre, Menyanthes trifoliata* and *Galium palustre*. Grassy vegetation height is 40-50 cm, mosses are represented by *Hypnum* mosses and cover 60-100% of soil surface.

Carex diandra associations occupy considerable areas only in Yaselda floodplain near Berioza and in the Dikoe mire. This association exists mainly in the mire patches where soil water table coincides with soil surface and micro- and nanorelief are poorly developed. Co-dominants in *Carex diandra* associations are *Eriophorum angustifolium (= polystachyon), Galium palustre, Comarum palustre, Menyanthes trifoliata* and *Carex omskiana*. Sedge height is 60-90 cm, moss cover is 25-80% with dominance of *Calliergon giganteum, Calliergonella cuspidata* and *Bryum ventricosum* (PARFENOV *et al.* 1973).

Carex appropinquata associations occupy considerable areas only in Zvanets and the Low Yaselda mires. The nanorelief consists of large tussocks 30-40 cm tall, soil water level varies between +5 and -30 cm. Co-dominants are *Carex omskiana, Caltha palustris, Galium palustre Comarum palustre, Agrostis stolonifera* and *Menyanthes trifoliata*. Vegetation height is 30-80 cm, moss cover exists only in patches with constant supplementary moisturising and is represented mainly by *Calliergonella cuspidata* and *Calliergon giganteum* (PARFENOV & KIM 1976). *Carex lasiocarpa* associations are most characteristic

for Dikoe mire and occupy only small areas in other mires. Soil water table usually coincides with soil surface, tussocks are absent. Co-dominants in *Carex lasiocarpa* associations are *Carex rostrata, Calamagrostis neglecta* and *Menyanthes trifoliata. Hypnum* mosses cover between 40 and 80%.

Calamagrostis neglecta associations are most common in Dikoe too, but are also regularly present in other mires in patches with constant excessive moisturising. Water level coincides with soil surface. Co-dominants in *Calamagrostis neglecta* associations are *Carex rostrata, C. lasiocarpa* and *Menyanthes trifoliata*. Moss cover is poorly developed due to the grass layer of considerable thickness and height (60-80 cm).

Table 6: Nesting phenology (start of incubation) of Aquatic Warbler in Belarus in 1998 (n = 33 nests). – *Brutphänologie (Datum des Brutbeginns) des Seggenrohrsängers in Belarus 1998 (n = 33 Nester).*

10-19.V	20-31.V	1-9.VI	10-19.VI	20-31.VI	1-9.VII	10-19.VII	20-31.VII
12	12	4	0	1	3	1	0

4.5. Phenology of Aquatic Warbler in Belarus

Analysis of our limited data allows us to conclude that the Aquatic Warbler has two main breeding periods within the breeding season (Tab. 6). Most birds start breeding around 15-25 May. Clutch initiation of second broods is more extended; in stable environment laying takes place mostly in the first decade of July. In early July 1998 only 4 nests were found, which can be explained by the destruction of all nests in one major breeding site (Yaselda floodplain) as a result of summer flooding. ♂ sing at similar intensity throughout the whole breeding season and become less active upon completion of the second clutch in late July. This sequence was observed in the Dikoe mire. When the second clutch is destroyed by summer flooding, birds may start building nests even in late July. This is indicated by increased activity of ♂ in Sporova and Zvanets in the last decade of July 1998. Since the average height of nests above water was 17 cm, an increase in water level by 30-40 cm from the initial leads to inundation of practically all nests.

4.6. Changes in Aquatic Warbler density

Density of Aquatic Warbler under stable conditions in the mire (no current impact of floods and fires) corresponds to the carrying capacity of the environment and depends on the trophic level and the corresponding vegetation structure (Tab. 3 & 4). The highest density is observed in mires characterised by elevated water mineralisation level and high oxygen content (Yaselda and Zvanets) within the described limits of vegetation height and structure (see 4.1.). Lower densities are observed in trophic-poor mires: Dikoe and Sporova.

The observed stability of warbler density in the Dikoe mire leads to the assumption that the density will remain more or less constant between years with absence of fires and floods. In those mire areas which suffered from spring burning, Aquatic Warbler density drops to a minimum level just after burning, the initial level being re-attained gradually. In the year of burning the density is minimal, after one year it is 50 % of the maximum and is restored completely only two years after the fire (Tab. 7). Birds build nests only on fire-safe or on partially burnt ground, i.e. areas which at the time of the fire had water level high enough to preclude burning of the moss and upper peat layer.

Depending on the character of relief and duration and height of the flood, increase in water level leads either to a re-distribution of density in the same mire or to complete abandonment of sites if these are no longer suitable for nesting, followed by migration to other mires (Tab. 8). For example, water level increase in Zvanets in 1998 started in late June/early July and reached its peak in mid-July. Water level remained high up to the end of July. At the beginning of July – when most birds are laying their second clutch – the majority of nests was inundated. However, there still remained limited areas suitable for nesting, especially high *Carex appropinquata* tussocks on relief elevations (around islands and less

Table 7: Change in Aquatic Warbler density (singing ♂/km²) in different years. – *Veränderungen der Seggenrohrsänger-Dichte (singende ♂/km²) in verschiedenen Jahren.*

(0) in late winter/spring of this year burning of vegetation was performed. – *In diesem Jahr wurde die Vegetation im Spätwinter/Frühjahr abgebrannt.*

(-1) burning of vegetation was performed in the previous year. – *Die Vegetation wurde im Vorjahr abgebrannt.*

50 density corresponds to the carrying capacity of the environment (more than 2 years elapsed since the last fire). – *Dichte entspricht der Habitatkapazität (mehr als zwei Jahre sind seit dem letzten Brand vergangen).*

Site name	Date of counts, number of singing ♂/km²			
	May 1995	May 1996	May 1997	May 1998
Yaselda (Peschanka)		**135**	25 (0)	70.5 (-1)
Yaselda (Kostuki)			**135**	35 (0)
Sporova				**40**
Zvanets	45 (-1)			**95**
Dikoe	**50**	**50**		**52.5**

expressed elevations). Apparently, a significant proportion of the ♀ continued building new nests toward the end of July, which is indicated by high activity of ♂ at the end of the breeding season.

In the Yaselda floodplain mire, a rapid increase in water level took place on 9-11 July 1998. On 9-10 July, 4 nests with fresh clutches were found, all of which were completely inundated on 11 July. In one nest with 5 eggs, 2 of them were included into a special tray in the nest ground, which means that the ♀ was tailoring her nest with every increase of water level. After all places suitable for nesting were flooded, the birds abandoned this part of the Yaselda floodplain completely (2,500 ha). Apparently they moved to another plot in the floodplain located 10-20 km further downstream around Lake Sporova. This is indicated by a doubling of the density of singing ♂ in the Sporova study plot by 22 July (Tab. 8). Singing ♂ were also noticed in other rather unfavourable mire parts, where they had been quite infrequent earlier in May and June. Despite bad weather – rain and wind – ♂ were singing intensively in the second half of the day and at night. Such hyperactivity is more common in mid-May, when most ♀ lay clutches. These data indicate the ability of Aquatic Warbler to move to new places in the middle of its breeding period and initiate breeding a second time.

The analysis of changes in density of the Aquatic Warbler in Belarus reveals two major factors determining the density, breeding success and population size in different years: changes in water level during the breeding period, and spring burning of vegetation.

In fen mires summer floods in time of abundant precipitation are a common phenomenon. Analysis of precipitation distribution in the region in different years allows us to conclude that summer floods occur here 5 times within 10 years on average. 15 mm precipitation within 12 hours occur in 6-7 out of 10 years in May - July. Almost full flooding of fen mires occurs also when precipitation exceeds 20 mm within 10 days. Long periods with high level of precipitation (permanent rain during 10 days) in the period April to October occurred in 4-5 out of 10 years (LOGINOV 1996). The amount of flooding of fen mires due to precipitation differs according to relief. For example, the Yaselda floodplain mires are completely flooded when the water level reaches 30-40 cm. In contrast, in the Zvanets and Sporova mires parts of the fen and many mineral islands remain dry at a water level of +40 cm and even more.

Spring burning of vegetation in the Yaselda and Zvanets mires, which are used for hay cutting, is performed at some plots or in the whole mire practically every year. Unfortunately, we have no information about the frequency of fire in natural mires without human impact. But we can assume that either occasional fires (caused e. g. by thunderstorms) and/or the oscillation of the mire surface of floodplain mires according to changes of the river water table has prevented overgrowing by bushes also in pre-human ages. This is indicated by the occurrence of more or less thick layers of pure sedge and sedge-*Hypnum* peat over big fen mire areas in the whole of central Europe.

5. Threats to the Aquatic Warbler

The best Aquatic Warbler habitats represent a transition stage of fen mire development and thus are more or less unstable ecosystems both due to natural processes and to interference from human (agricultural) activities. The main negative factors affecting adversely the major Aquatic Warbler breeding localities in Belarus are:

• **Drainage and land reclamation campaigns:** We estimate from retrospective balance of open fen mire areas since the 1960ies, that the suitable habitat area and population size of Aquatic Warbler must have suffered a decline of more than 90 % within the last 30 years, mainly due to drainage, land reclamation and peat extraction. Following old topographical maps, vegetation maps and information given by the state drainage and land reclamation institutes of Belarus (Belmeliovodhoz and Belgiprovodhoz), nearly 15,000 km² of fen mires have been drained since 1960. The currently known breeding habitats were identified on a high-quality vegetation map of Belarus from 1977 (YURKEVICH *et al.* 1979), scale 1 : 750,000, and could be associated precisely with two vegetation units (41a and 41b), which still covered about 3,800 km² on this map. These vegetation types have decreased to about 440 km² in 1995-1998 (see map Fig. 13), out of which ca. 154 km² (15,400 ha) are thought to be still suitable for Aquatic Warbler (see Tab. 1; open sedge fen of medium

Site name	plot size (ha)	Date of counts, density (singing ♂/km²)		
		May 21-29	June 22-26	July 20-25
Yaselda (Peschanka)	68	70.5	62	0
Yaselda (Kostuki)	40	35	35	0
Sporova (Kokoritsa)	40	40	? (no data)	95
Zvanets	122	95	91.6	100
Dikoe	80	46.2	52.5	12
Prostyr	40	0	0	0

Table 8: Changes in density of singing ♂ of Aquatic Warbler (per km²) in Belarusian fen mires throughout the breeding season in 1998. – *Veränderungen der Dichte singender Seggenrohrsänger-♂ in belarussischen Niedermooren während der Brutsaison 1998.*

vegetation height with shallow water or water-saturated ground cover of green mosses).

In some large mire tracts, drainage and land reclamation was still ongoing in 1995/1996, e.g. in the southern part of the Zvanets mire. Despite of the recent establishment of a big nature reserve along the Yaselda river and around lake Sporova ("zakaznik of national importance", c. 190 km^2), several km^2 of adjacent open sedge fen (excluded from the reserve) around Kokoritsa south of lake Sporova, which are also inhabited by Aquatic Warblers, are scheduled for drainage in the near future.

Apart from direct destruction, formerly a much higher proportion of fen mires must have been suitable for the species due to traditional use by hay-making and burning. An increasing percentage of remaining fen mires is no longer suitable due to abandonment of agricultural use, followed by overgrowing with reeds, bushes and succession forests (see below).

• **Impact from former or recent drainage measures in the surroundings** is leading to changes in water regime of the major mire tracts, although most of them have by now been declared protected sites. This phenomenon is observed at each of the six largest mire tracts, which are all bordered by drained lands. Changes in the natural water regime may lead either to decrease in ground water level (Dikoe, Sporova, partly Zvanets) or to an increase of it, causing running-water conditions (Yaselda-Berioza). These changes in general are promoted by the presence of old drainage canal networks in the mires and direct proximity to large drained areas as well as damming of river floodplains. Usually, changes in water regime accelerate the vegetation succession (change of vegetation associations, overgrowing of open fen by shrubs and succession forests).

• **Change in river water regime:** Canalisation of the upper course of Yaselda from the source to the upper limits of the newly established nature reserve downstream Berioza, construction of a water reservoir and the Selets fish farm upstream of the reserve and decrease of the floodplain width due to damming and drainage measures downstream of the reserve altogether leads to the change of river water regime. This causes complete absence of flooding during the relatively dry years and high mid-summer flooding after strong rainfall or clearing of the fishponds.

• **Water pollution and eutrophication:** Increase in water pollution has been observed during recent years in Yaselda and Pripyat rivers. Concentrations above the maximum tolerable levels for oil products, Cu and phenols were observed during the whole study period. Furthermore, excess levels were recorded for NO_2 and P in 1996. Organic pollution from cattle breeding farms seems to increase as well. Mineralisation leads to minerals being washed downstream to flooded Aquatic Warbler areas, thus speeding up the rate of vegetation succession.

• **Overgrazing** is an important disturbance factor in some mires, causing changes in nanorelief and plant associations.

• **Hay cutting:** Early cutting (before June 15) may lead to increased nest mortality of Aquatic Warbler and some other mire bird species. On the other hand, another important threatening factor connected with cutting is the decrease in areas cut for hay making. Abandoned areas tend to overgrow by willow shrubs or reeds and become unsuitable for open sedge fen specialists like Aquatic Warbler.

• **Spring burning** of old vegetation needs careful application according to the actual ecological situation. Spring burning of mire vegetation may have especially negative effects on vegetation and animals during dry springs with no flooding, when the upper peat layer, small roots and insects are burning along with the dry grassy vegetation. Most birds, including Aquatic Warbler and Corncrake *Crex crex*, tend to avoid such burned grasslands. On the other hand, controlled burning in winter or early spring can be an appropriate management tool for long-term maintenance of habitat quality and prevention of vegetation succession.

• **Vegetation succession** and increase of shrubs: Decrease in traditional land use by hand grass cutting (scything) of mires, especially those with altered water regime, leads to increase of shrub occurrence and overgrowing of open sedge fens. This decrease in traditional use is mainly connected with recent increase of large drained hay meadow tracts.

6. Consequences for conservation and research

All large breeding sites of Aquatic Warbler in Belarus were affected by various kinds of adverse human activities during the last 20-30 years, leading to changes in water regime and acceleration of vegetation succession. Following the recent results of our Aquatic Warbler and fen mire surveys in Belarus and our current knowledge about the major threatening factors, the following conservation measures are proposed:

a) Establishment and improvement of protected sites:

- Creation of a zakaznik of national importance in the Yaselda floodplain downstream of Berioza (already realised in spring 1999);

- improvement of the borders of Dikoe, Sporovsky and Zvanets zakazniks, especially inclusion of unprotected open fen mire parts;
- transmission of the Dikoe zakaznik under the administration of the Belaveshkaya Forest National Park (already realised in spring 1999).

b) Management of the most important sites:
- Development of profound management plans for the most important wetlands of Polessie: Pripyat floodplain, Dikoe, Yaselda-Berioza, Sporova, Zvanets and Prostyr (elaboration of management plans for the four largest mire tracts has started in spring 1999, funded by the British Darwin Initiative);
- implementation of the management plans, including establishment of suitable administration structures; this means especially:
- evaluation of the current situation and restoration of the fen mire hydrological regime in the Dikoe, Sporova and Zvanets zakazniks;
- planning and implementation of management measures to limit overgrowth of mires by willow shrubs and reedbeds.

c) Ecological research and monitoring:
- Establishment of an ecological monitoring system (long-term monitoring plots) in the most important mire and floodplain sites to control the changes in water regime, vegetation structure and population changes in indicator species, especially Aquatic Warbler, and to evaluate the success of management measures (started in 1998, funded by the German Otto Foundation for Environmental Protection);
- study of fen mire hydrology and the possibilities of their restoration, primarily for Dikoe and Sporova mire tracts;
- study of the vegetation succession in fen mires (causes of and possible ways of preventing the overgrowth by willow shrubs and reedbeds);
- study on the Aquatic Warble ecology (diet, habitat structure, ecological niche, breeding success/ productivity, competition) in various mire types as a basis for sound conservation measures (research projects started in 1998/99, supported by the British Royal Society for the Protection of Birds, the German Max Planck Institute, the Otto Foundation and the British Darwin Initiative).

d) Long-term development program:
- Restoration of natural hydrological conditions (water table level) in partly drained or negatively impacted fen mires;
- establishment of nature reserves and appropriate administration of all important fen mires;
- restoration of fen mires on exhausted peat cuttings and drained lands unprofitable for agricultural use.

7. Zusammenfassung

Kozulin, A. & M. Flade 1999: Bruthabitat, Siedlungsdichte und Gefährdungssituation des Seggenrohrsängers *Acrocephalus paludicola* in Belarus (Weißrußland). Vogelwelt 120: 97 – 111.

Mehr als die Hälfte des Weltbestandes des global bedrohten Seggenrohrsängers konzentriert sich im Südwesten der Republik Belarus (Weißrußland). Zum Zeitpunkt der Entdeckung der weißrussischen Population war diese immer noch in starker Abnahme infolge Habitatzerstörung durch Entwässerung und Nutzungsaufgabe begriffen. Seit 1995 wurden alle potentiellen Seggenrohrsänger-Brutgebiete systematisch untersucht und ab 1996 Studien zur Populationsentwicklung, Habitatstruktur, Bruterfolg und Nahrungswahl begonnen. Die belarussische Population wird zur Zeit auf 7,300 - 13,000 singende Männchen in 12 Brutgebieten mit zusammen 440 km^2 Niedermoorfläche (davon 154 km^2 für Seggenrohrsänger geeignet) geschätzt, wobei sich allerdings über 95 % auf nur 6 große Niedermoorkomplexe konzentrieren. Der Seggenrohrsänger ist eine sehr stenotope Art, die einige wenige Niedermoortypen stark bevorzugt, in anderen dagegen völlig fehlt. Die vom Seggenrohrsänger bevorzugten Moore sind durch Großflächigkeit, mesotrophe bis schwach eutrophe Nährstoffverhältnisse, sehr konstanten Wasserstand nahe der Mooroberfläche (+0-10 cm) während der Brutzeit, mittlere Vegetationshöhe (60-70 cm) und -dichte sowie einen hohen Deckungsgrad an Braunmoosen gekennzeichnet (Braunmoos-Seggenriede auf mesotroph bis schwach saurem Basen-Zwischenmoor). Viele oder die meisten Seggenrohrsänger scheinen an zwei Jahresbruten beteiligt zu sein, wobei Fluktuationen der Bestände und Gebietswechsel während der Brutsaison in Abhängigkeit von Wasserstandsschwankungen häufig vorkommen (Tab. 8). Die Dichte wird auch Abbrennen der Vegetationsdecke beeinflußt: Nach Abbrennen einer Fläche im zeitigen Frühjahr fällt die Seggenrohrsänger-Dichte auf ein Minimum und steigt erst im zweiten Jahr nach dem Feuer wieder auf das vorherige Niveau an (Tab. 7). - Einer nachträglichen Flächenbilanz der intakten Niedermoore in Belarus folgend ist zu vermuten, dass der Seggenrohrsänger-Bestand in den letzten 30 Jahren um über 90 % abgenommen hat. Neben direkter Moorzerstörung durch Entwässerung und Torfabbau zählen andere Veränderungen des Wasserregimes, Wasserverschmutzung und Eutrophierung, Überweidung, zu frühe Mahd, Abbrennen zu ungünstigen Zeitpunkten (zu spät im Jahr oder wenn das Moor zu trokken ist) und Sukzession (Überwachsen der Seggenflächen mit Gebüschen oder Schilf) infolge Nutzungsaufgabe hydrologisch veränderter Moore zu den Gefährdungsfaktoren. In Kap. 6 werden Folgerungen für Naturschutz und Forschung zusammengefaßt.

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Habitat selection of Aquatic Warbler *Acrocephalus paludicola* in Poland: consequences for conservation of the breeding areas

Janusz Kloskowski & Jaroslaw Krogulec

Kloskowski, J. & J. Krogulec 1999: Habitat selection of Aquatic Warbler *Acrocephalus paludicola* in Poland: consequences for conservation of the breeding areas. Vogelwelt 120: 113 – 120.

In parallel to the countrywide census of Aquatic Warblers *Acrocephalus paludicola* in Poland in 1997, data on breeding habitat characteristics were collected. Using multivariate statistics, the habitat features could be ordered along two gradients: from open areas with rare, coarse-grained patches of shrubs to those dominated by scattered shrubs, and from flat grass fen with shallow water to distinctly tufty, deeper flooded, and reed-dominated areas. These two gradients generally correspond to two successional processes in wetlands occupied by Aquatic Warblers: (a) colonisation by shrubs due to lowering of the water table and abandonment of agricultural use, and (b) invasion of reed associations in the vicinity of drainage channels. Densities of singing Aquatic Warbler ♂ were negatively correlated with the first gradient, but there was no significant relationship with the second. Reed associations are inhabited by Aquatic Warblers in Western Pommerania, where reeds are harvested every year, whereas singing ♂ were only occasionally recorded in this habitat in other parts of Poland, where no industrial reed exploitation occurs. Areas occupied by Aquatic Warbler and unoccupied, closely associated habitats differed with regard to both gradients. This indicates that breeding habitat suitability may be the most important factor limiting Aquatic Warbler populations. We conclude that overgrowing of open wetlands by shrub and reed vegetation is the principal reason for breeding habitat loss in Poland. Conservation measures are discussed, including those associated with low-intensity agricultural use of the wetlands comprising Aquatic Warbler breeding grounds.

Key words: *Acrocephalus paludicola*, habitat selection, vegetation structure, successional changes, conservation measures.

1. Introduction

Human-induced habitat alterations, mainly those associated with reclamation of wetlands and transformation of agricultural practices are among the major factors responsible for the dramatic decline of the Aquatic Warbler in most of its breeding range (BAUER & BERTHOLD 1997). There is an urgent need to describe the parameters of the species' preferred habitat, as these data constitute the basis for conservation programmes and models predicting future population trends on the basis of predicted habitat changes. While it is generally acknowledged that habitat destruction may be a limiting factor to Aquatic Warbler populations, little quantitative data characterising breeding habitats are available. LEISLER (1981) focused on habitat segregation between sympatric *Acrocephalus* species while the study of SELLIN (1989a, b) refers mainly to the Greifswald (NE Germany) population breeding in reed associations of brackish water, a rather marginal habitat of the Aquatic Warbler in Poland (KROGULEC 1995; this study). However, SELLIN's comparisons of breeding habitats in Greifswald and in Biebrza Marshes (NE Poland) demonstrated that structural vegetation aspects are presumably more important than the species composition of the local vegetation cover. Consequently, in this study, which aims at the description of habitats occupied by Aquatic Warbler in Poland, we concentrated on structural characteristics, although data on plant communities were collected as well.

To assess the role of habitat availability in the breeding areas, most studies compare patches occupied by the species of interest versus randomly chosen (usually adjacent) habitat patches (PRESCOTT & COLLISTER 1993; SEAMANS & GUTIERREZ 1995). Similarly, we predicted that if lack of breeding habitat is a factor limiting Aquatic Warbler populations, there should be differences in habitat features of occupied versus unoccupied areas. The research was conducted during the most recent 1997 census of the entire known population of the species throughout Poland (KROGULEC & KLOSKOWSKI 1997).

2. Study area and methods

Habitat measurements were carried out as a part of the census of singing ♂. All important breeding sites were surveyed from 19 May to 2 June 1997 with the exception of the upper course of Narew River valley, where a population of ca. 60 singing ♂ was recorded previously (KROGULEC & KLOSKOWSKI 1997). In most breeding areas a second survey followed between 3 and 18 June 1997. The sites were visited at intervals of at least two weeks. Trained surveyors searched all potentially suitable habitat patches working in groups of usually 4-5 individuals walking ca. 50 m apart from each other. These patches of 60-300 ha within natural boundaries were censused between 19:00 and 21:00 h, when the ♂ sing most persistently (DYRCZ & ZDUNEK 1993). The locations of ♂ were mapped at a scale of 1:25,000, and their density per km^2 of the National Grid squares was calculated. When any inaccuracies in assigning the recorded ♂ to squares were suspected or when the measurements might not have been representative because of pronounced heterogeneity of the habitat within a square, the squares were excluded from the statistical analysis.

Measurements and surveys of singing ♂ were performed on the same days. Five habitat variables were measured for each 1 km^2 square:

1. Water level (the depth of water level above the soil surface) was obtained as the mean of five measurements at random points by leaning a measure stick on the ground, not piercing the layer of vegetation.
2. Numbers of reed stalks counted on two randomly chosen 0.5 m^2 areas were summed to give the "reed density" per 1 m^2.
3. Four degrees of complexity of "ground profile" with regard to herbaceous vegetation were chosen visually, using a qualitative scale: 1 - flat, grass dominated fen; 2 - flat areas, vegetation with no grass; 3 - mosaic of flat and tufty patches; 4 - tufty.
4. Shrub number was estimated by counting all shrubs on four 100 x 0.5 m transects radiating in compass directions from a point constituting an approximated centre of the habitat patch occupied by singing ♂ in the given square. The four counts were averaged to give the mean number per 100 m. Shrubs were defined as such when exceeding 0.5 m in height. Total length of stretches covered by shrubs along four 100 m transects was measured for the approximated area of greatest singing activity inside the square.
5. A shrub cover index was calculated by multiplying the proportion of shrub layer per unit distance by the modal height of shrubs estimated by eye in four 100 m x 0.5 m transects. The 'patchiness' of the shrub layer was assessed summing up the number of shrub 'patches' (including trees) in the four transects and dividing it by their total length. A 'patch' was defined as at least one shrub/tree of height > 0.5 m at a distance of >1 m from another.

Records of dominating plant species were made and later compared with phyto-sociological cards (where available) of the surveyed areas. Subsequently, the data on plant associations was categorised into four habitats: *Carex* marshes (including both pure sedge mires and moss mires); wet meadows; reedbeds; calcareous *Cladium* marshes. However, as no quantitative estimate was made of

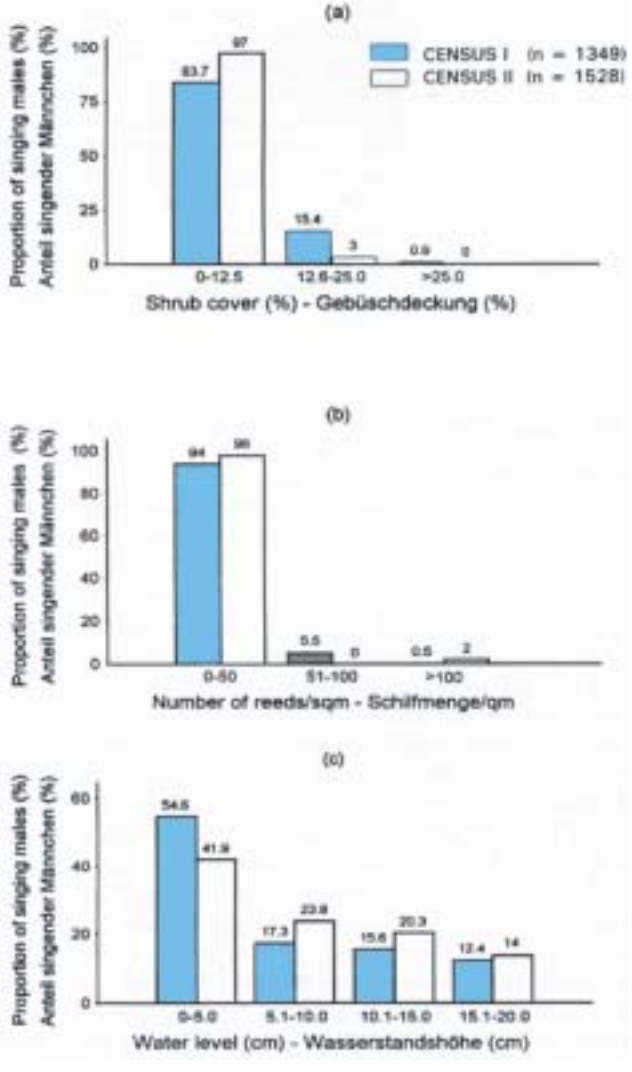

Fig. 1: (a) Occurrence of singing ♂ of Aquatic Warbler in areas of different shrub cover index. – *Vorkommen singender Seggenrohrsänger-♂ in Flächen mit unterschiedlichem Gebüschdeckungsindex.*
(b) Occurrence of singing ♂ of Aquatic Warbler in areas of different reed density. – *Vorkommen singender Seggenrohrsänger-♂ in Flächen mit unterschiedlicher Schilfdichte.*
(c) Water depth and occurrence of singing ♂ of Aquatic Warbler. – *Wasserstands-*

Table 1: Correlations of Aquatic Warbler breeding habitat features with the first two principal components of the PCA. – *Korrelationen der Strukturmerkmale des Bruthabitates des Seggenrohrsängers mit den ersten beiden Hauptkomponenten der Hauptkomponenten-Analyse.*

habitat variables	PC1	PC2
shrub cover	0.95	0.10
shrub 'grainnes'	0.91	0.04
water level	0.33	0.67
reed density	0.06	0.70
ground profile	-0.38	0.62

Table 2: Correlations of habitat features of occupied and unoccupied 1 km² squares with the first two principal components. – *Korrelationen der Strukturmerkmale der besetzten und unbesetzten Quadratkilometer-Gitterfelder mit den ersten beiden Hauptkomponenten.*

habitat variables	PC1	PC2
shrub cover	0.69	0.23
shrub 'grainnes'	0.81	-0.16
water depth	0.58	0.32
reed density	-0.10	0.80
herbaceous layer structure	0.15	0.81

the ground cover of plant associations belonging to these habitat, the integration of vegetation data into the statistical analysis was not attempted. In addition, data on the current conservation status and agricultural land-use like mowing, cattle grazing etc. were collected, although no quantitative estimates were attempted.

3. Statistical analysis

Principal component analysis (PCA) was performed on the correlation matrices of the habitat variables to transform the original sets of habitat variables into uncorrelated sets of factors comprising the interrelated variables. For this multivariate statistical analysis we used only squares where at least one singing ♂ was recorded during the first census. VARIMAX rotation was used in order to obtain a clear-cut interpretation of the factors. To determine the associations between the habitat features and Aquatic Warbler densities, the principal components were related to the estimated numbers of ♂ singing per 1 km² square.

To compare characteristics of occupied versus unoccupied areas, squares where at least one singing ♂ was recorded, were classified as 'positive', those without Aquatic Warblers as 'negative'. To describe the common gradient of habitat characteristics PCA was conducted on both 'positive' and 'negative' squares. Data from the maritime region, where Aquatic Warblers breed in a very specific habitat of harvested reed, were excluded. The principal components were derived from a correlation matrix of the transformed original variables. The axes were VARIMAX rotated. Subsequently, the principal component scores referring to the occupied and unoccupied habitats were compared using an analysis of variance (ANOVA). Additionally, untransformed original variables describing the occupied and unoccupied habitats were compared using the MANN-WHITNEY-U test.

It must be noted that the unoccupied squares used in our study were not taken at random, but were surveyed as apparently suitable breeding habitats. These areas were closely associated and visually similar to occupied habitats or/and breeding of Aquatic Warbler was previously documented there. However, these squares were distributed within all the most important Aquatic Warbler breeding areas in Poland. Furthermore, as the species appears to be a habitat specialist, it would have been difficult to obtain a representative sample by selecting random plots in the vicinity of the occupied sites.

4. Results

4.1. Breeding habitat description

Two independent habitat gradients were determined by PCA performed on the data from 83 squares. The first PCA component ordered the Aquatic Warbler breeding areas along a gradient from open, shrubless places, to areas dominated by high and abundantly scattered shrub patches. It accounted for 40.2% of total variance; the second, independent component ordered the counted squares from flat, reedless areas with shallow surface water to more deeply flooded and tufty areas with high reed density. It explained 25.6 % of the total variation in habitat complexity (table 1). Singing ♂ density was inversely related to the first principal component (PC 1: $F = 4.0$, $p < 0.05$), but no significant relationship was found with the second (PC 2: $F = 1.34$, ns). Frequencies of occurrence of singing ♂ in relation to shrub cover, reed density and water depth in the squares are presented in the Fig. 1a-c.

From 1,251 singing ♂ for which data on plant associations in the breeding habitat were available, 658 (52.6 %) were recorded in *Carex* marshes, 255 (20.4 %) in carbon marshes (exclusively in the breeding grounds near Chelm), 135 (10.8 %) in wet meadows and 203 (16.2 %) in reedbeds. However, 176 singing ♂ from the latter total were recorded in one breeding area in the maritime region whereas in all other parts of the country only 55 ♂ (4.4 %) were observed in reeds (mainly small patches inside of other vegetation types).

4.2. Occupied versus unoccupied habitats

A total of 65 'positive' and 27 'negative' squares was used for this analysis. The first component of PCA axis ordered the habitat features along a gradient from open fens without any shrubs to areas dominated by densely scattered shrub patches. It accounted for 35.1 % of total variance. The second component ordered the investigated squares from flat turf of grass to markedly tufty reedbeds and explained 24.5 % of the total variation in habitat complexity (Tab. 2). The PCA scores for the 'positive' and 'negative' squares

differed; Aquatic Warbler apparently avoids areas overgrowing with shrubs and reeds and distinctively avoids areas with a tufty ground profile (Fig. 2; the first principal axis of ANOVA: $F = 3.92$, $p < 0.05$; the second axis: $F = 10.44$, $p = 0.002$). From the original habitat variables only "ground profile" ($U = 499.0$, $p = 0.001$) and "shrub cover" index ($U = 390.5$, $p < 0.001$) differed significantly between the occupied and unoccupied squares.

5. Discussion

5.1. Breeding habitat selection of Aquatic Warbler

Our results show that the species occurs in areas limited by succession of shrubs and reeds. Wetlands subjected to water extraction and drainage are influenced by two successional processes, generally represented by the two PCA factors in our analysis: (1) overgrowing of the open fen by bushes (mainly *Salix* spp.) due to water table depression brought about by drainage systems (PALCZYÑSKI 1985) and (2) local encroachment of reed communities associated outside the flooded zones of rivers with drainage ditches. These two processes seem to pose the major threats to habitat suitability for Aquatic Warbler in Polish wetlands. Although no negative association was found between the second habitat gradient of the increasing reed density and numbers of singing ♂, Aquatic Warblers were only exceptionally recorded in squares with reed density exceeding 100 stalks/m^2. Apparently, breeding of Aquatic Warblers in reedbeds in Western Pommerania contrasts with the rare occurrence of singing ♂ in reed associations in other parts of the country. However, this may be attributable to the fact that our records did not discriminate between high previous-year dead stems and low, newly grown green shoots. In fact only in Western Pommerania regular reed exploitation took place, thus ensuring predominance of young stalks. In the Narew valley small numbers of Aquatic Warblers were recorded after burning the reedbeds (KROGULEC & KLOSKOWSKI 1997). Apparently Aquatic Warblers occupy reed associations only in their earliest successional phases. This suggestion is confirmed by the colonisation of brackish water grasslands near Greifswald by Aquatic Warblers after invasion of weak and low reed vegetation due to reduction of the grazing intensity in the 1970s (SELLIN 1989). Remarkably, in our research no singing ♂ were recorded at reed densities of 200-300 stems/m^2, regarded by SELLIN (1989) as optimal conditions for breeding Aquatic Warbler.

Although Aquatic Warblers inhabit various plant associations, the range of structural characteristics of the habitat is relatively narrow. The fact that no areas were occupied when the average depth of water above the soil surface exceeded 20 cm may be explained by the female's way of foraging by collecting large arthropods from the ground (SCHULZE-HAGEN 1991) and the danger of flooding of the nests, as has been recorded in the Chelm *Cladium* marshes (pers. obs.).

5.2. Does breeding habitat availability limit Aquatic Warbler populations?

Although the differences in structural features of occupied and unoccupied habitat patches were significant for only two univariate habitat variables, they were clear in terms of multivariate combinations of the original variables. Bearing in mind the fact that most of the unoccupied squares had earlier been inhabited by the species, the character of the differences indicates that the main reason for the short supply of suitable breeding habitats in Poland are successional changes toward formations dominated by shrubs and locally by reeds. The Aquatic Warbler is presumably unable to colonise the areas due to a lack of relevant morphological adaptations relative to other *Acrocephalus* species

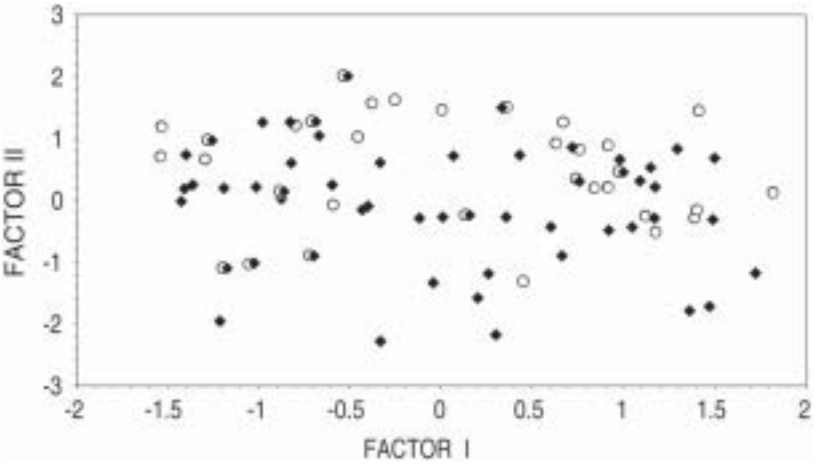

Fig. 2: Scores for 1 km^2 squares occupied (◆) and unoccupied (○) by Aquatic Warbler on the first two principal-component axes. – *Einordnung der vom Seggenrohrsänger besiedelten (◆) und unbesiedelten (○) Flächen nach den zwei Hauptachsen der Hauptkomponenten-Analyse.*

Fig. 3: Aquatic Warbler habitat in the calcarious Chelm marshes (E-Poland) with dominating *Cladium mariscus*. – *Seggenrohrsänger-Habitat in den Kalksümpfen von Chelm (Ost-Polen), mit dominierender Binsenschneide* Cladium mariscus. Photo: Authors.

Fig. 4: Open sedge fen with Cotton grass *Eriophorum angustifolium* in the southern basin of Biebrza marshes, where breeding density of Aquatic Warbler is high. – *Offenes Seggenmoor mit Schmalblättrigem Wollgras* Eriophorum angustifolium *im Süd-Becken des Biebrzatales; hohe Brutdichte des Seggenrohrsängers.* Photo: Authors.

Fig. 6: Sedge fen with high tussocks of *Carex appropinquata* are only a suboptimal habitat for Aquatic Warbler; southern basin of Biebrza marshes, June 1992. – *Seggenriede mit hohen Bulten der Schwarzschopfsegge* Carex appropinquata *sind nur ein suboptimaler Seggenrohrsänger-Lebensraum; südliches Biebrza-Becken, Juni 1992.* Photo: M. FLADE.

Fig. 7: Male Aquatic Warbler at his singing post. – *Seggenrohrsänger-♂ auf der Singwarte.* Photo: A. BALINSKI.

Fig. 5: Habitat loss caused by vegetation succession due to abandonment and (probably) changes in water regime: shrubs and reed are overgrowing open sedge fens in the southern basin of Biebrza marshes. – *Habitatverlust durch Sukzession als Folge von Nutzungsauflassung und (wahrscheinlich) Veränderungen des Wasserhaushaltes: Gehölze und Schilf überwachsen ein offenes Seggenmoor im südlichen Biebrza-Becken.* Photo: Authors.

which are competitively superior in such habitats (LEISLER *et al.* 1989).

Another argument for the importance of suitable habitat is the rapid increase of the relatively isolated Aquatic Warbler population in the Hortobágy Puszta (Hungary) after an accidental improvement of habitat quality (KOVÁCS & VÉGVÁRI 1999). Establishment of smaller populations clearly associated with changes in habitat characteristics were observed in other breeding sites, e.g. Greifswald (D. SELLIN), Sloñsk (JERMACZEK). In fact, all breeding grounds in Europe from which Aquatic Warbler disappeared, suffered pronounced habitat alterations (BAUER & BERTHOLD 1997).

Our findings do not diminish the possible importance of other causes for the species decline, especially those acting away from the breeding grounds. Accelerated habitat alterations in the wintering quarters, even if not decisive now, may become decisive soon. However, at the present stage of knowledge, breeding habitat destruction appears to be the crucial factor responsible for the Aquatic Warbler global population decline.

While under negative anthropogenic impacts for decades, Aquatic Warbler habitat availability also seems to be regulated by human-independent stochastic environmental factors like floods and droughts. Short-term seasonal changes in breeding habitat availability may be important with regard to the second broods. In most Aquatic Warbler breeding areas in Poland surveyed twice at intervals of >2 weeks, densities of singing ♂ increased after 3rd June (the assumed second brood period) relative to densities during the first census, indicating that density of late (often second) broods may even exceed that of early (first) broods. These differences are apparently not attributable to inaccuracies in the counts, as they were clear in all major breeding areas of the country. We have not tried to quantify the differences, but they seem to be linked to changes in habitat characteristics like depression of water table in the flooded zone of the Biebrza river (pers. observ.). Observations of DYRCZ & ZDUNEK (1993) on the Biebrza fen mires indicate that most ♀ Aquatic Warblers change the place for laying the second clutch. Distribution of ♀ is presumably determined by seasonal changes in food abundance (DYRCZ & ZDUNEK 1993). Considering the high proportion of second broods (WAWRZYNIAK & SOHNS 1977), sometimes (presumably subtle) changes in habitat structure and composition during the interval between first and second brood may be crucial for the population recruitment and deserve further work, using a larger set of variables and smaller-scale habitat units.

Theoretically, any species constrained by rapidly changing landscape dynamics should have extensive dispersal tendencies (PROBST 1986), as selection pressures favour flexible exploratory behaviour (FAHRIG & MERRIAM 1994). This seems to be confirmed by the extremely low return rate of Aquatic Warblers ringed as nestlings (DYRCZ & ZDUNEK 1993). As the interplay between the rate of landscape alterations and rate of change in dispersal behaviour is crucial for the species survival (FAHRIG & MERRIAM 1994), further research is urgently needed on dispersal characteristics of the species.

5.3. Recommendations for management of breeding areas

The stenotopic character of the Aquatic Warbler in regard to rapid successional changes of some of the breeding areas in Poland implicates the need of flexible ways of habitat conservation, based on monitoring of year-to-year habitat changes and suited to the local hydrological, successional and socio-economical regimes. Considering the factors mentioned above, some disturbance like mowing, controlled burning or cattle grazing, when not taking place during the nesting period, may be beneficial for the species, impeding the succession of shrubs and contributing to removal of dead top-growth of reeds. In fact, abandonment of mowing in the Biebrza valley is probably responsible for the expansion of bushes (PALCZYÑSKI 1985). In the southern Biebrza basin, at a few sites which were burnt down at least one year before the 1997 census, an increase in numbers of Aquatic Warbler was observed compared to the 1995 survey (KROGULEC 1995). However, an experimental approach at a scale large enough to affect birds within a whole local population (GREEN 1994) is needed to verify and specify this relationship. Such manipulative experiments are possible in Poland, where outside Biebrza marshes Aquatic Warblers breed in relatively small, discrete populations.

The traditional forms of agricultural land-use of the Aquatic Warbler breeding sites should be promoted and as most of them have been abandoned due to economical reasons, schemes of financial support for the agriculture practices, which may increase the habitat suitability for the species, should be worked out. Still these activities, although recommended for areas under low-intensity human use where Aquatic Warbler occur, cannot replace long-term hydro-technical programmes of improving water management of large wetland areas affected by prior drainage. Only in this way will it be possible to maintain such wetlands at the optimal stage of succession for the warbler. Locally such projects already exist. These works should aim both at the increase in water retention abilities in breeding areas independent of rivers and widening the range of floods in river valleys occupied by Aquatic Warblers.

As Aquatic Warblers inhabit various plant communities, an understanding of the various successional processes is urgently needed for reliable simula-

tions of future population trends. In addition, population trends within discrete breeding areas should be described in relation to local habitat changes. Further research is also needed regarding the relations between habitat characteristics and warbler breeding productivity on different breeding grounds, because the complex social organisation of the species (DYRCZ 1989) may constitute a factor limiting its distribution to high productivity marshland ecotones (LEISLER & CATCHPOLE 1992).

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6. Zusammenfassung

Kloskowski, J. & J. Krogulec 1999: Habitatwahl des Seggenrohrsängers *Acrocephalus paludicola* in Polen: Folgerungen für Schutzmaßnahmen in den Brutgebieten. Vogelwelt 120: 113 – 120.

Vom 19. Mai bis 2. Juni 1997 wurden parallel zur Bestandsaufnahme des Seggenrohrsängers in Polen Daten zur Struktur der Bruthabitate gesammelt. Aufgrund der Messungen wurden fünf Habitatvariable definiert: Gebüschverteilung („patchiness“), Gebüsch-Bedeckungsgrad, Wasserstand, Schilfhalmdichte und Bodenrelief (Bultigkeit). Als Grundeinheit wurde für diese Untersuchungen ein Quadrat (Gitterfeld) von 1 km^2 mit mindestens einem singenden ♂ definiert. Eine Hauptkomponentenanalyse (PCA) wurde angewendet, um mehrere korrelierte Variablen zu wenigen voneinander unabhängigen Faktoren zu transformieren. Die untersuchten Bruthabitate wurden mit Hilfe der folgenden zwei Gradienten geordnet: Von offenen, gebüschfreien Arealen zu Flächen, die durch hohe, zerstreut stehende Büsche dominiert sind, sowie von homogen flach strukturierten, schilffreien Gebieten mit seichtem Wasserstand zu höher überfluteten, dichten Röhrichten mit stark bultigem Bodenrelief. Die beiden Gradienten entsprechen in etwa den zwei Sukzessionsrichtungen in den Brutgebieten des Seggenrohrsängers: Fortschreitende Verbuschung infolge von Wasserentzug sowie Schilfsukzession in der Nähe von Meliorationsgräben. Die Anzahl der singenden ♂ pro 1 km^2 war signifikant negativ korreliert mit der ersten PCA-Hauptkomponente, keine signifikante Korrelation bestand mit der zweiten. In Polen wurde der Seggenrohrsänger nur sehr selten in verschilften Teilen der untersuchten Gebiete registriert, mit Ausnahme von Westpommern, wo in den entsprechenden Gebieten jedes Jahr das Schilf für industrielle Zwecke gemäht wurde und die Vögel die niedrigen und schmächtigen diesjährigen Schilfbestände besiedelten.

Die von Seggenrohrsängern besiedelten (65 Quadrate) und unbesiedelten Gebiete (Auswahl von 27 optisch geeigneten und/oder früher besiedelten, jedoch aktuell nicht besetzten Quadraten in Nachbarschaft zu besiedelten Brutgebieten) unterschieden sich in den strukturellen Komplexmerkmalen der PCA. In den unbesiedelten Flächen war die Sukzession weiter fortgeschritten. Da alle entsprechende Habitate besiedelt waren, scheint die Qualität des Bruthabitats ein Hauptfaktor der Begrenzung der Populationsgröße zu sein. Die Ergebnisse zeigen, daß der Seggenrohrsänger ein schmales Habitatspektrum beansprucht und daß die größte Bedrohung für seine Bruthabitate in Polen von der sukzessiven Verbuschung ausgeht. Im Kontext der Ergebnisse werden Managementmaßnahmen zum Schutz der Bruthabitate diskutiert, insbesondere hinsichtlich extensiver Pflege- und Bewirtschaftungsmaßnahmen wie Beweidung, Mahd oder kontrolliertem Abbrennen.

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Population size and habitat of the Aquatic Warbler *Acrocephalus paludicola* in Hungary

Gábor Kovács & Zsolt Végvári

Kovács, G. & Z. Végvári 1999: Population size and habitat of the Aquatic Warbler *Acrocephalus paludicola* in Hungary. Vogelwelt 120: 121 – 125.

The population of the Aquatic Warbler in Hungary has been increasing steadily since the first breeding record in 1971. A population increase from 19 singing ♂ in 1971 to 586 singing ♂ in 1997 was observed. The total population is estimated to comprise about 600 singing ♂, which concentrate on the Hortobágy Puszta, the only known breeding area in Hungary. Some possible breeding sites in eastern Hungary have not yet surveyed. The breeding range recently expanded eastwards in the southern part of the Hortobágy National Park. The species prefers larger patches of lowland marsh vegetation, sometimes with no water at all.

Keywords: *Acrocephalus paludicola*, population development, population increase, Hortobágy, habitat preferences.

1. Introduction

Although the first definite breeding record of Aquatic Warbler in Hungary was in 1971 in the Hortobágy Puszta, there are several claims of breeding from the first half of the 20th Century that were not confirmed later or which referred to egg collections lost in the Second World War (SZABÓ 1974). Breeding biology, inter- and intraspecific behaviour, population trends and means for conservation of the Aquatic Warbler were thoroughly studied on the Hortobágy (SZABÓ 1974; LEISLER 1988; KOVÁCS 1994). Although monitoring of the species has been carried out since 1959, this did not include all possible breeding sites (SZABÓ 1974; KOVÁCS 1994), and some large populations are thought not to have been found yet. However, so far no other breeding area was found in Hungary outside Hortobágy (KOVÁCS 1998). In 1996 and 1997 a field study was conducted in the southern part of the Hortobágy in order to identify habitat preferences and population densities.

2. Material and Methods

The Aquatic Warbler has been systematically looked for since 1959 in suitable habitat by only a couple of people (SZABÓ 1974, KOVÁCS 1994) up to the early 1980s. Since then, with the increase in the number of Hungarian birdwatchers, it became possible to monitor larger areas with the help of specifically trained people. New breeding sites were found, and it became a special task for the Hortobágy National Park staff and some NGOs to include this species in their yearly monitoring programmes. Censuses by counting singing ♂ (SCHULZE-HAGEN 1989; LEISLER 1988; WAWRZYNIAK & SOHNS 1977) normally yield the absolute population size, since the breeding habitat is quite patchy and no extrapolation of the number of singing ♂ is necessary.

Singing ♂ have been counted in the 18 most important areas from 1971 onwards and in two more since 1993. Habitat patch sizes in the present study vary between 5 and 99 ha, averaging 23.86 ha. The habitat patches have been occupied for 4 - 26 years (13.85 years on average). Their distance from the first breeding site on the Hortobágy varied between <1 and 26 km (5.78 km on average).

These investigated habitat patches held 65 % (1996) resp. 72% (1997) of the total number of singing ♂ on the Hortobágy. Counts were made at least twice a week during the period 10th May - 20th June, starting two to one hour before sunset. Size of the occupied area and vegetation type were recorded for each habitat patch. Vegetation type was characterised in terms of plant associations. Table 1 shows the list of plant associations covering 30 % of at least one habitat patch. Each habitat patch is given a single vegetation type category by linking the abbreviations (see Tab. 1.), starting with the most abundant vegetation type followed by the less abundant one. Each category includes only association types covering at least 30 % of the given habitat

Table 1. List of plant associations covering at least 30 % of at least one habitat patch of the Aquatic Warbler on the Hortobágy. – *Liste der Pflanzengesellschaften, die mindestens 30 % wenigstens eines vom Seggenrohrsänger in der Hortogágy Puszta besiedelten Habitatfleckens bedecken.*

Plant association	Abbreviation
Agrostetum albae	Ag
Alopecuretum pratensis	Al
Agrostio-Beckmannietum	Be
Bolboschoenetum maritimi	Bo

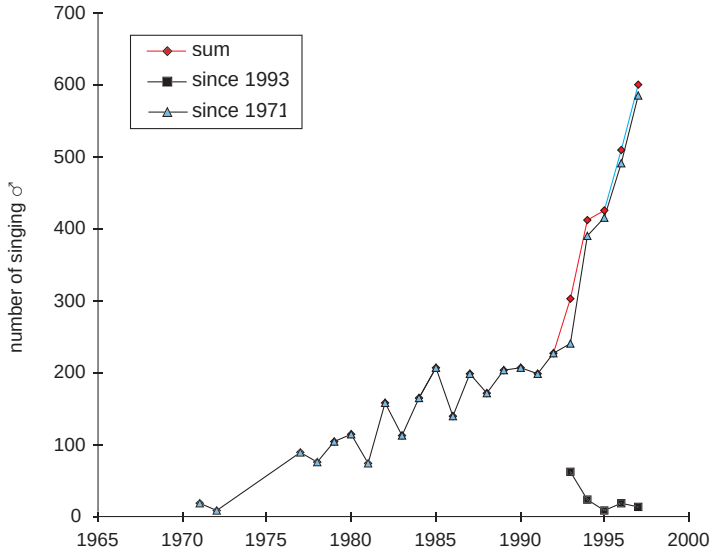

Fig. 1: Population trend of the Aquatic Warbler in Hungary in areas monitored since 1971 and 1993. – *Bestandsentwicklung des Seggenrohrsängers in Ungarn in Gebieten, in denen der Bestand seit 1971 bzw. 1993 alljährlich erfaßt wurde.*

patch. In this way 9 categories were found: Al; AlAg; AlBe; AlBeAg; AlBo; AgAl; Be; BeAl; Bo. Additional variables are the density of singing ♂, number of years between 1971 and the year of the first occupation of the habitat patch, duration of occupation in years and distance from the first breeding site.

3. Results

3.1. Distribution

In Hungary, according to presently available information Aquatic Warblers breed exclusively on the Hortobágy, but some other potential sites, mostly in Eastern Hungary, have not yet been surveyed. Distribution on the Hortobágy is shown in Fig. 4. The population is concentated in the southern, strictly protected part of the Hortobágy National Park.

3.2. Population trend and habitat changes

The population trend (number of singing ♂) is shown in Fig.1. The first breeding site of the Aquatic Warbler, where the highest population densities are found up to now (see map, Fig. 4), is located in a marsh that is used as an emergency reservoir in case of large floods in the river Tisza. The first significant increase in the number of singing ♂ was observed in 1977 after a large flood in early spring. This year was followed by rather rainy years up to 1982, a period in which the population steadily increased with some fluctuations. The next seven years up to 1989 were dry, and the population increased more slowly with larger fluctuations. In the period 1990 and 1994, when there was an unusual drought with the exception of 1991, the population increased strongly with no fluctuation at all. This trend continued up to 1997, regardless of whether years were dry (1995) or very rainy (1996-1997). Decreases occurred only locally, e.g. in the easternmost population that was found and monitored since 1993, where the habitat was burnt down in the summer of that year.

The number of singing ♂ are stable or increasing especially in areas flooded artificially early in the spring (KOVÁCS 1994). The population increased very quickly in areas where mowing was stopped (KOVÁCS 1994).

3.3. Habitat preferences and densities

3.3.1. Effects of habitat patch size and duration of its occupation

In 1996, out of a total of 331 singing ♂, 2-70 (16.55 on average) were found per habitat patch, while in 1997 out of a total of 423 ♂, 0 to 80 (21.15 on average) were singing per habitat patch. Density of ♂ varied between 8 and 13.3 ♂/10 ha in 1996 (6.2 on average) and between 0 and 20 ♂/10 ha (average 8.2) in 1997.

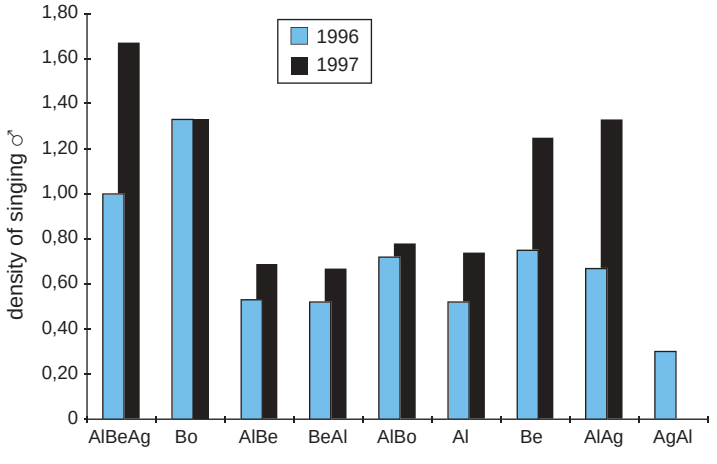

Fig. 2: Density of singing ♂ in various vegetation types 1996-1997. Abbreviations see Table 1. – *Dichte singender Seggenrohrsänger in verschiedenen Vegetationstypen (vgl. Tab. 1 und 2) in der Hortobágy Puszta 1996-1997.*

Table 2: Correlations between habitat variables and population characteristics. – *Korrelationen zwischen Habitatvariablen sowie Anzahl und Dichte singender Seggenrohrsänger in den einzelnen Habitatflecken der Hortobágy.*

Variables	Habitat patch size		Years between 1971 and first occupation		Years of occupation		Distance from first breeding site	
	1996	1997	1996	1997	1996	1997	1996	1997
no. of singing ♂	0.6701**	0.7028**	-0.1382	-0.1984	0.1382	0.1984	-0.1788	-0.2944
density	-0.1361	-0.1596	0.1338	0.0521	-0.1338	-0.0521	0.0842	-0.1049

** $p < 0.01$, n=20

Table 2 shows correlations between the number of singing ♂, ♂ density, and habitat patch size, years between the first breeding record on the Hortobágy and the first occupation of the area, duration of occupation, and distance from the first breeding site. A significant correlation was found only between the number of ♂ and the size of the habitat patch. The number of singing ♂ did not correlate significantly with the distance from the first breeding site, although sites further away tended to hold fewer ♂. No correlations were found between habitat variables and ♂ density. However, larger breeding sites tended to have lower densities.

3.3.2. Effects of vegetation type

Density of singing ♂ in different vegetation types are shown in Fig. 2. The highest density was in Bo in 1996, while in 1997 it was in AlBeAg. The lowest density in 1996 as well as in 1997 was found in AgAl. Figure 3 shows the number of singing ♂ in different vegetation types. It was in AlBo, where most ♂ were found both in 1996 and in 1997. Lowest numbers in 1996 and in 1997 were found in AgAl and Bo, respectively. In vegetation types, where Al is dominant (71% of total study area), 75 % of the singing ♂ were found in both years.

4. Discussion

4.1. Distribution

Although there is no evidence for breeding Aquatic Warblers in Hungary outside Hortobágy, the recent discovery of some small populations indicates that the species is easily overlooked. Possible areas include large parts of eastern Hungary. Populations on the Hortobágy concentrate around the first breeding site with some satellite populations in the south-eastern part of the Hortobágy.

4.2. Effects of habitat changes on the population trend

According to aerial photos, marshland vegetation was very short in the middle of the century, perhaps due to the more intensive pastoral use of the Hortobágy, while it is generally undergrazed nowadays (MOLNÁR 1997). Although changes in habitat structure have not been studied in the area, it could be a very important factor for the increase of the Aquatic Warbler population. Vegetation types found in the present study are the same that have been observed at the first breeding record (SZABÓ 1974).

Water level does not seem to play an important role in the habitat preferences of the species, since it was quite often found breeding in dry grassland vegetation (KOVÁCS 1994). In addition, Aquatic Warbler showed a very strong population increase in unusually dry years (1992-1994). According to some authors, the Aquatic Warbler's tolerance of rather dry habitats can be explained by the avoidance of interspecific competition with Sedge Warbler *Acrocephalus schoenobaenus*. The latter, more aggressive, species prefers higher water levels (SZABÓ 1974; LEISLER 1988; KOVÁCS 1994).

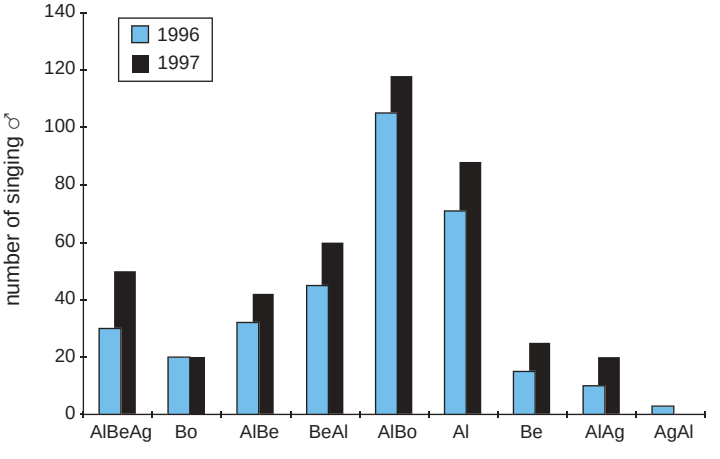

Fig. 3: Number of singing ♂ in various vegetation types 1996-1997. – *Verteilung der absoluten Zahl singender Seggenrohrsänger auf verschiedene Vegetationstypen (vgl. Tab. 1 und 2) in der Hortobágy Puszta 1996-1997.*

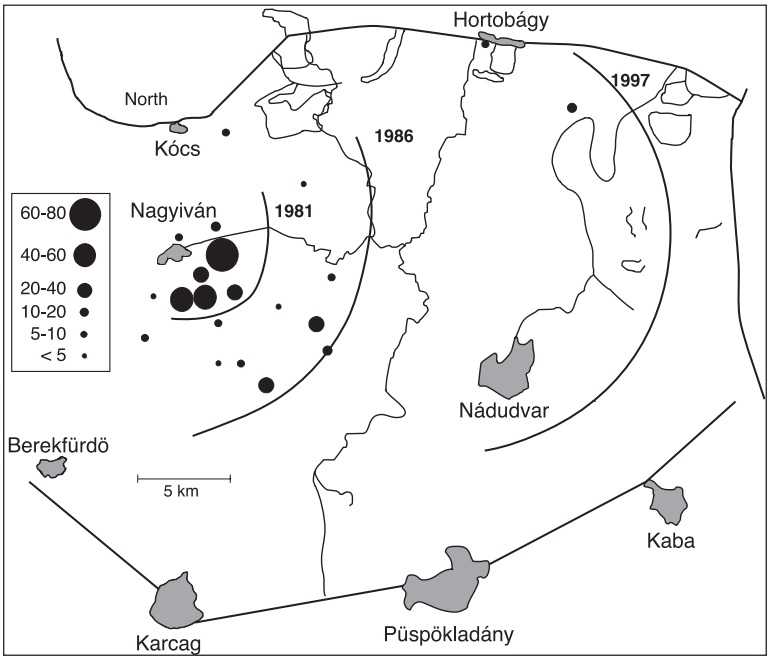

Fig. 4: Map of distribution, progression of occurrence (lines with year indicate distributional limits) and number of singing ♂ Aquatic Warblers on the Hortobágy. – *Karte von Verbreitung, Ausbreitungsgrenzen (Linien mit Jahreszahlen) und Anzahl singender ♂ des Seggenrohrsängers in der Hotobágy Puszta.*

4.3. Nature conservation

In order to maintain high water levels up to the end of the first brood of Aquatic Warbler (as well as for other species), most important habitats are flooded artificially. This means is also effective against uncontrolled mowing. In some areas, where cutting has been prohibited to improve the habitat for Aquatic Warbler, its population started to increase rapidly (KOVÁCS 1994). As a rule of thumb, in Aquatic Warbler habitats mowing is postponed up to July to let the birds finish breeding in safety. In some cases fires have damaged important breeding sites, so fire control plays an important role in the nature conservation fieldwork of the National Park. Habitat restoration projects of the Hortobágy National Park concentrate on wetlands, with special regard to Aquatic Warbler, which is a strictly protected species in Hungary and which breeds only in the strictly protected zone of the National Park.

5. Zusammenfassung

Kovács, G. & Z. Végvári 1999: Bestand, Bestandsentwicklung und Habitatwahl des Seggenrohrsängers *Acrocephalus paludicola* in Ungarn. Vogelwelt 120: 121 – 125.

Seit dem ersten Brutnachweis 1971 hat der Bestand des Seggenrohrsängers in Ungarn beständig zugenommen. Es wurde ein Bestandszuwachs von 19 singenden ♂ 1971 auf 586 singende ♂ in 1997 beobachtet. Der ungarische Gesamtbestand von aktuell etwa 600 ♂ konzentriert sich in der Hortobágy Puszta, dem einzigen bekannten Brutgebiet in Ungarn, wenngleich einige weitere mögliche Brutgebiete in Ostungarn bisher nicht untersucht wurden. Das Brutgebiet der Art hat sich im Verlauf der beschriebenen Zeitperiode im südlichen Teil des Hortobágy Nationalparks nach Osten ausgedehnt. Die Art bevorzugt größere Flecken von Niedermoor-Sumpfvegetation, die manchmal überhaupt kein anstehendes Wasser aufweisen. Die besiedelten und bevorzugten Vegetationstypen werden beschrieben (Tab. 1 und 2, Abb. 2 und 3). Die Zunahme des Seggenrohrsängern in Ungarn ist in wesentlichen Teilen auch auf speziell auf die Art ausgerichtete Managementmaßnahmen der Nationalparkverwaltung zurückzuführen: Reduzierung der Beweidungsintensität, Herauszögern des Beweidungsbeginns auf Mitte Juli, künstliche Überflutung der Habitate im zeitigen Frühjahr, dadurch auch Vermeidung von ungewollter/unkontrollierter Mahd zur Brutzeit.

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News – Nachrichten

Aquatic Warbler Conservation Team founded

In the course of a workshop of Aquatic Warbler experts from all countries of its breeding range in early April 1998 in Brodowin, Brandenburg, Germany, an "Aquatic Warbler Conservation Team" (AWCT) was founded. The AWCT is a "non-official" group of experts who co-operate in research and conservation of this globally threatened species. The major goal of AWCT is to co-ordinate and support the implementation of the *BirdLife International* Species Action Plan for the Aquatic Warbler, to monitor its success and to periodically prepare draft proposals to bring the Action Plan up to date. Information about research and conservation activities all over Europe are exchanged as well as experiences in fieldwork and conservation management. National or international projects may be initiated by the Team. The AWCT works under the auspices and supervision of *BirdLife International* and is funded by the *Royal Society for the Protection of Birds* (RSPB) which is the British BirdLife partner. Besides the AWCT there are several other expert teams concerned with other globally threatened species (e.g. Slender-billed Curlew, Corncrake).

The contact address of AWCT is: Dr. Martin FLADE, Dorfstraße 60, D-16230 Brodowin, Germany; phone (home) +33362-70123; phone (office) +3334-5822-303; fax (office) +3334-5822-44;
e-mail martin.flade@munr-lags.brandenburg.de.

Aquatic Warbler Desk Study

The Aquatic Warbler is one of 24 globally threatened bird species regularly occurring in Europe. Although much is known about its breeding and summer habitats, the same cannot be said of its winter quarters in Africa. The published species action plan (HEREDIA, B., L. ROSE & M. PAINTER, eds. (1996): Globally threatened birds in Europe - Action plans (Council of Europe Publishing, F-67075 Strasbourg, Cedex), regards the threat of habitat loss in winter quarters as unknown and the need for protection of this species and its habitat in the winter quarters as high. It is hoped that, once more information is available regarding Aquatic Warbler's winter quarters, more can be done to conserve this threatened habitat specialist.

A desk study into the wintering sites of the Aquatic Warbler was initiated to collect all current records and sightings of this species in any African country. A short questionnaire was designed and sent to a wide range of African contacts which included BirdLife Partners and BirdLife Representatives, Wetlands International Country Co-ordinators, private individuals with expert African knowledge and other organisations and museums. Data from these questionnaires is still being collected. In addition, a literature search is being undertaken to locate all published sightings. Another source of information is ringing and ringing recovery data which is also being followed up. An Internet search is taking place to locate information about specimens/skins held in museum collections.

There may be some sources which have so far been overlooked. If you have any information which may be relevant to this study, please write to Mrs. Kim GUTTERIDGE or Dr Norbert SCHÄFFER, European Programmes, The Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, UK; e-mail:
norbert.schaffer@rspb.org.uk.

A report based on the above findings will be published later this year.

Kim Gutteridge
Norbert Schäffer