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

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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 km² 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 km², 60,980 km² in Belarus and 70,940 km² 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 km², but decreased to currently about 444 km² (of which 154 km² 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 km²) 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. 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.

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.

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 ♂/km², 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 ♂/km²).

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 km²), 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.

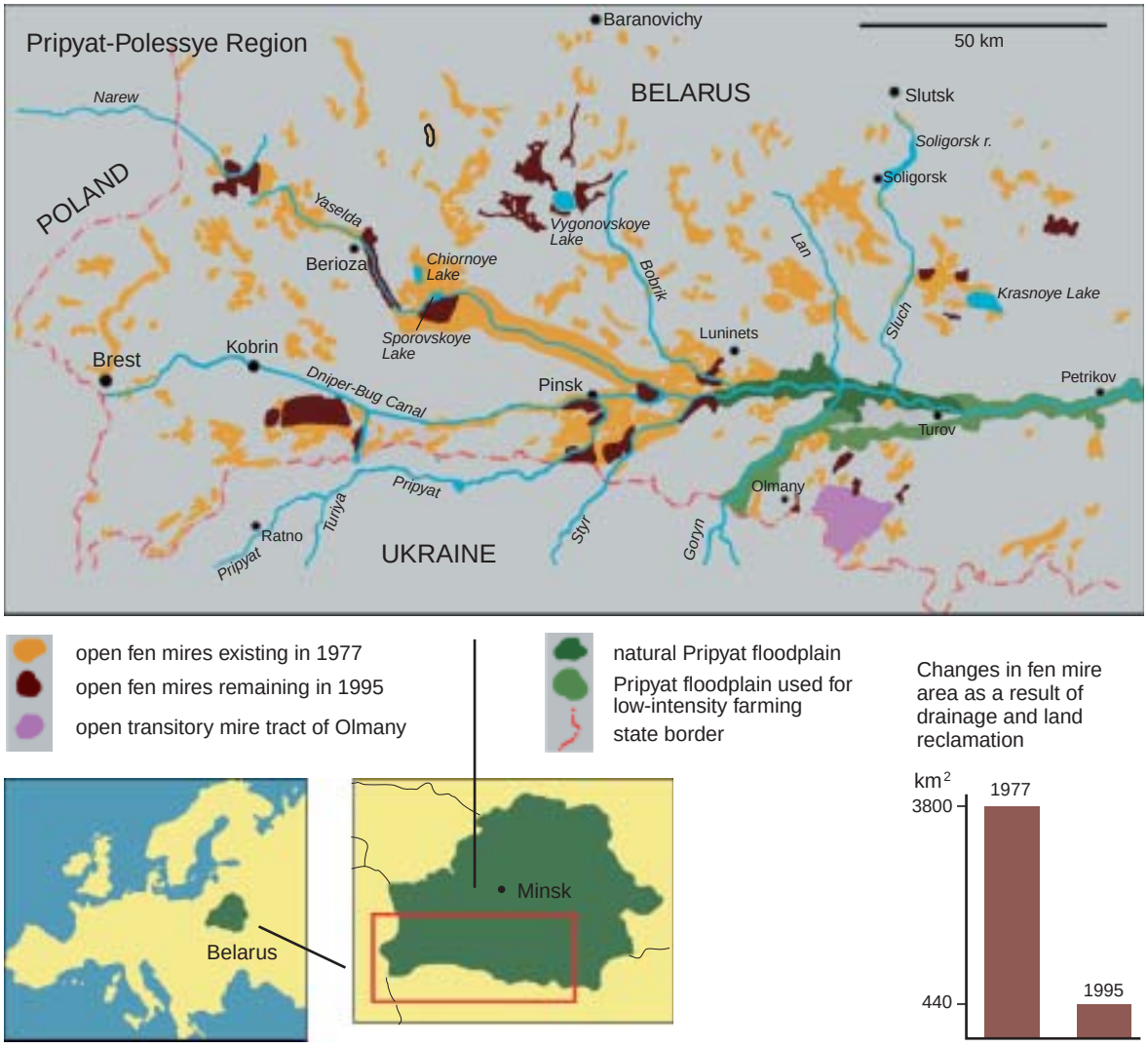

Fig. 13: Map of recent fen mires in Southwest-Belarus and fen mires drained and transformed since the early 1970ies. – *Karte der heute noch erhaltenen und der seit den frühen 1970er Jahren meliorierten Niedermoore in SW-Belarus.*

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).

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.

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

4.6. 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.

8. References

AQUATIC WARBLER CONSERVATION TEAM 1999: World population, trends and threat status of the Aquatic Warbler *Acrocephalus paludicola.* Vogelwelt 120: 65-85.

CRAMP, S. (ed.) 1992: Birds of the Western Palaearctic. Vol. VI. Oxford: University Press.

DATSKEVICH, V. A. 1972: Avifauna of Bialowiez Forest and its vicinities. Bialowiez Forest. Res. 5: 184-222 (in Russian).

DEMENTIEV, V. A. 1977: Geography of Byelorussia. Minsk: Vysheishaya Shkola (in Russian).

DOROFEEV, A. M. (ed.) 1993: Red Data book of the Republic of Belarus. Minsk: Belarusian Encyclopedia (in Russian and Belarusian).

FEDYUSHIN, A. V. & M. S. DOLBIK 1967: Birds of Byelorussia. Minsk: Nauka i Tekhnika.

LOGINOV, V. (ed.) 1996: Climate of Belarus. Minsk.

MARTSINKEVICH, G. I., N.K.KLITSUNOVA, O. F. HARANICHEVA, O. F. YAKUSHKO & L. V. LOGINOVA 1989: Landscapes of Byelorussia. Minsk, Vysheishaya Shkola. (in Russian).

NIKIFOROV, M. E., B. V. YAMINSKY & L. P. SHKLIAROV 1989: Birds of Byelorussia: handbook to eggs and nests. Minsk: Vysheishaya Shkola.

PARFENOV, V. I. & G. A. KIM 1976: Dynamics of meadow-mire flora and vegetation under the impact of drainage. Minsk: Nauka i Tekhnika (in Russian).

PARFENOV, V. I., G. A. KIM, G. F. RYKOVSKY 1973: Vegetation of Yaselda River floodplain and its possible changes under the impacts of drainage melioration. P. 111-159 in: PARFENOV, V.I. (ed.) Studies of Forest Phytocenoses. Minsk: Nauka i Tekhnika (in Russian).

RYKOVSKY, G. F. 1980: Mosses of the Berezinsky Nature Reserve. Minsk: Nauka i Tekhnika.

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 after 1991. Vogelwelt 120: 87-96.

TUCKER, G., & M. HEATH 1994: Birds in Europe: their conservation status. Cambridge: BirdLife International.

YURKEVICH, I. D., D. S. GOLOD & V. S. ADERIKHO 1979: Vegetation of Byelorussia, its cartographing, protection and use. Minsk: Nauka i Tekhnika (in Russian).

YURKEVICH, I. D., E. A. KURGANOVA, N. A. BURTYS & N. I. PETRUCHUK 1975: Meadows of Pripyat River floodplain. Problems of Polessie 4: 3-28 (in Russian).

YURKEVICH, I. D., E. A. KURGANOVA, N. I. PETRUCHUK & S. R. SHCHERBACH 1972: On the classification of Pripyat River floodplain meadows. Arch. Acad. Sci. BSSR. Ser. Biol. Sci. no. 3: 5-10 (in Belarusian).

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