Factors Affecting Fluctuations of the Aquatic Warbler Acrocephalus paludicola Population of Byelarussian Mires

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Factors affecting fluctuations of the Aquatic Warbler *Acrocephalus paludicola* population of Byelarussian mires

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Abstract. Data on the density of Aquatic Warbler and plant associations in the marshes of the Sporovskiy reserve (Byelarus') were collected between 1996 and 2003. The species density changed between years from 135 to even 0 males per km^2. The density and numbers of these birds are governed mainly by changes in the groundwater table caused by floods, droughts or fires. Aquatic Warblers breed successfully when the groundwater table coincides with the topsoil level; the optimal water table lies in the range from 12 cm above the soil to 5 cm below it. Between 1981 and 2002 successful first-clutch breeding occurred 11 times (47.8%); in only 4 years was second-clutch breeding successful (17.3%). First and second clutches both failed in 9 years (39%). The pattern of changes in the population size and data on the recovery of the population size following such unfavourable years indicates that the key factors governing the overall population size are not migration or wintering conditions, but rather the state of the breeding biotopes. Active management of fenland still in its natural state is therefore of paramount importance.

Key words: Aquatic Warbler, *Acrocephalus paludicola*, population size, habitats, dynamics, fluctuations, water level

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INTRODUCTION

The Aquatic Warbler is a habitat specialist which breeds on open sedge fen mires. Large-scale drainage of wetlands in the XX century resulted in disappearance of this species from most of its known range (Aquatic Warbler Conservation Team 1999). The contemporary breeding range of the species is much smaller than the original one, and is intermittent. Recent studies have revealed that the core of the contemporary breeding range of the species is located in the Polesye region (Kozulin et al. 1998). The European population of the species amounts to 13 000–21 000 of singing males. Most of them were found in Byelarus', Ukraine and Poland (Aquatic Warbler Conservation Team 1999). Number of the species in Europe continue to fall and fluctuate significantly between years (Aquatic Warbler Conservation Team 1999, Kovacs & Vegvari 1999).

There were no data on the contemporary dynamics of the species number at selected habitats recently, just as there was no analysis of factors defining the fluctuations of the population sizes. The number of Aquatic Warbler at important habitats declines and is characterized by significant yearly fluctuations (Aquatic Warbler Conservation Team 1999). Lack of monitoring data prevents from answering the basic question: what brings about fluctuations of the species numbers at its important breeding habitats. Is it changes in the state of the breeding biotopes, or is it the conditions of wintering grounds and concentration sites on migration? Additionally, there is still lack of clarity as to what factors define fluctuations of the population size at breeding biotopes, as well as about how exactly these factors impact the size of the population. Once answers to these questions are identified, proper management of the habitats of this threatened bird species can be planned for and implemented.

Aquatic Warbler breeds on fen mires with specific vegetation composition and hydrological regime (Kozulin & Flade 1999). Sometimes even insignificant changes in the proportion of associations may cause a decline in the density of the species or even its disappearance. Taking that into account, the project made a special focus on the study of vegetation successions.

In 1996 a study was initiated to identify and analyze key factors defining the number of Aquatic Warbler at one of its key habitat sites in Byelarus', which hosts about 9% of the European population of the species (Kozulin et al. 1999). One of the practical objectives of the study was to provide background for management of breeding biotopes, as well as to learn about the key preferences of the species regarding its habitat: these should be secured as a result of management of the site.

STUDY AREA

The study was carried out in biological reserve "Sporovskiy" (52°23"N, 25°20"E). It contains one of the least transformed fen mires in Europe. The territory of reserve is a flat alluvial plain with lakes, river valleys, above-floodplain terraces and unique mineral islands. Mires a single entity (covering 75% of the area of the reserve) stretching along the Yaselda river for about 35 km. The mire cover 19 384 ha, and the area suitable for Aquatic Warbler breeding — 2 650 ha. The territory of the reserve can be divided into two parts. The first part located between villages Peschanka and Mlynok is a narrow extremely waterlogged floodplain of the Yaselda river stretching for some 25 km. The Yaselda river flows though the center of the floodplain, and reveals an extremely meandering channel overgrown substantially by water plants. Reedbeds are some 10–100 m wide, accompany the flow on both sides of the river. The reedbeds are followed by a constantly flooded valley 50–100 m wide. The rest of the floodplain 500–2000 m wide on both banks of the river is a typical fen sedge mire.

The second part of the reserve (lake Sporovskoye district) is an extremely widened Yaselda river floodplain were fen mires of various trophic status dominate, but which also contains a lot of mineral islands. The channel of the river in this part is characterized by well-formed banks.

The main part of the reserve is covered by open fen mires (8 373 ha, 43.2 %), fen mires with mosaically placed shrubs (3 470 ha, 17.9%) and shrubby mires (795 ha, 4.1%). Forest and shrub communities are poorly represented. Numerous low hills and low elevations (mineral islands) are scattered across the mire and along the opposite rim of the river floodplain.

Hydrological features

Since the mire is located in a river floodplain, the water level in it fully depends on the water level dynamics in the Yaselda river. Before drainage of the Yaselda catchment the water regime of the river was characterized by long and high spring floods (March through mid-May), summer no-flood period (August) and infrequent rainfall events throughout the summer. Drainage of the river floodplain for agriculture, rectification of the channel, construction of Selets water reservoir and fish-farm in the upstream part, all resulted in radical changes in the Yaselda river water discharge. Since the upstream part of the river is fully under artificial regulation, spring floods are almost absent, which in turn leads to encroachment of river channel by water vegetation and creation of jams of floating vegetation islands which in the past would be taken off downstream by the rapid flood water. Currently the water level in Sporovskiy mire fully depends on the patterns of water resource use at the Selets reservoir and fish-farm. In humid years and in years with excessive precipitation supplemental discharge of water from the reservoir leads to long inundation of the mire; in dry years most water is used to secure the needs of the fish-farm, which is accompanied by a drastic drop of the water level in the mire below permissible levels. In early August, during fish-collection the water in the fish-farm is being discharged into the river, resulting in long-lasting inundation of its floodplain (August–October).

Description of monitoring plots

Meadow and wetland vegetation of the fen mires in Sporovskiy reserve is represented mainly by communities of eutrophic mires (associations *Phragmitetum communis, Caricetum rostratae Rubel, Caricetum elatae*), waterlogged meadows (associations *Phalaridetum arundinaceae, Glycerietum aquaticae, Caricetum gracilis*) and moist meadows (associations *Molinietum coeruleae, Caricetum paniceae).* By area *Carex elata* are dominating among grass communities of the *Phragmitetea* class.

The mire, however, is not uniform: it can be provisionally divided into three sub-types each characterized by specific proportions of vegetation communities and hydrochemical parameters. One monitoring plot was established at each of the sub-types. The main hydrochemical parameters of the

Table 1. Description of monitoring plots.

Characteristics	Plots		
	I	II	III
Size (ha)	60	40	40
Size of monitoring plots (m)	1500×400	1000×400	1000×400
Hydrochemical parameters:			
PH	7.03	6.25	6.41
Cumulative nitrogen (mg/l)	1.31	0.99	2.36
Chlorides (mg/l)	34.1	16.3	13.2
Sulfates (mg/l)	5.7	23.9	33.5
Hydrocarbons (mg/l)	176.3	68.7	73.2
Common phosphorus (mg/l)	0.028	0.040	0.066
Mineralization (mg/l):			
1998	322.4	135.8	104.4
2001	289.7	145.4	163.2
Most important vegetation communities (% of total area):			
Caricetum elatae	89.1	81.1	38
Caricetum appropinquatae	–	–	12.7
Caricetum rostratae	4.5	5.2	2.9
Caricetum lasiocarpae	–	–	38.6

mire at each monitoring plot are shown in Table 1. The first monitoring plot (Plot I — Peschanka) was located in the Yaselda river floodplain, 8 km downstream of the Selets water reservoir and Byerioza town. This part is characterized by the highest production. It is worth noting that the production value of the site can change among years depending on whether or not the site was flooded in spring. The second monitoring plot (Plot II — Kostyuki) is located 14 km further downstream. The self-purification capacity of the river defines a lower production value of this part of the mire. The third monitoring plot (Plot III — Kokoritsa) is located along the river downstream of Sporovskoye lake. This part is characterized by poor trophic content which increase in those years when this part gets flooded. It is important to take into account that here a number of drainage ditches flow into the river leading to its pollution.

Differences in the productivity and water mineralization of various mire parts (Table 1) explain why the monitoring plots would have dissimilar proportions of vegetation associations. As an example, the projective coverage of *Caricetum elatae* community, which is typical of mires with rich mineral content, dominates in Plot I and at the same time, Plot III has large proportion of *Caricetum lasiocarpae* community which is typical for poor soils (Table 1).

METHODS

The estimate of the number of singing males for the whole mire was drawn on the basis of data on their density on three monitoring plots during first clutch and the area suitable for breeding of the species at each mire part. In order to reproduce a picture of the long-term dynamics of the species number, changes in the area of suitable breeding biotopes of the mire were studied on the basis of aerial photos dated 1951 and 1992.

Data on the singing males' density was used to estimate the state of the population. Counts were performed every year from 1996 through 2002. Each monitoring plot was covered by 100 × 200 m rectangles. When marked, the plot was mapped. The width of each counting strip was 200 m. Each count was performed by 2–4 persons at the same time depending on the amount of transects. The count started 1 hour before sunset. All singing males of Aquatic Warbler were counted. Each male was mapped on a pre-prepared schematic map.

Every year two count sessions were performed: the first one from 25 May to 5 June (first clutch), while the second one from 1 to 10 July (second clutch). The need for a second count was driven by the fact that summer floods often brought about re-distribution of birds within the breading season.

Monitoring of vegetation was carried out annually at each plot using standard geobotanic methods (Braun-Blanquet 1964).

During the study additional data were also gathered, like: time of the last fire, climatic conditions, and hydrochemical parameters. The level of ground water relative to soil surface was measured every year in late May and early July, using a simple ruler dug into soil. The soil level in between the tussocks was assumed a zero mark for measuring the water table. Water table below the zero mark ware recorded with a minus, those above the zero mark — with a plus. The fire events could influence the breeding place and feeding resources thus the Aquatic Warbler densities. Therefore the fires were evaluated in following scales: A, B and C:

A — burning of vegetation occurred while the water level is equal to soil surface (about 0). Only small spots of old vegetation preserved. The number of breeding places is limited because of altered masking conditions. Fire causes destruction of some part of old vegetation with wintering insects;

B — burning of vegetation occurred while the water level is 5 cm below soil surface (-5 cm). Dry vegetation is totally burned, upper peat layer is partly damaged. Normal breeding places are lacking due to total burning of old vegetation. Feeding base is considerably damaged;

C — burning of vegetation occurred while the water level is 10–15 cm below soil surface. Dry vegetation, upper layer of moss cover and part of upper peat layer are totally burned. Breeding places are lacking, feeding base is greatly damaged.

For fine-tuned measurement of the negative water table, a small well was dug in front of the ruler.

In order to reproduce long-term changes in the population size, information on water levels in late May and early July in the central part of the mire (Plot I) was analyzed for years from 1981 to 2002, based on the data about water level in the Yaselda river at Byerioza check-point, located 2 km from the plot.

Trends in the vegetation dynamics (changes in the floristic composition and production) were studied for 5 years based on the example of *Caricetum elatae menyanthetosum trifoliatae* subassociation, which is dominating at Plot I.

RESULTS

Changes in the proportion of important biotopes over the last decades

Comparative analysis of aerial photos (scale 1 cm = 100 m, 1951–1992) has indicated that the area of open fen mires had over the last several decades shrunk by 24.6% (from 11 107 ha to 8 374 ha). This is an outcome of extensive shrub encroachment on open mires: the area of mires where shrubs cover more than 40% has increased by 86.4% (1 861 to 3 470 ha), the area of forests has increased by 17.3% (3 121–3 666 ha in 1992).

Vegetation dynamics

Analysis of the data shows that the majority of changes in the floristic composition, abundance (coverage) of species, and their viability are related to fluctuations of the groundwater table (Table 2). Thus, the prolonged and high flooding in 1998 and 1999 during the most active vegetation period (May-June) stimulated development of species preferring excessively humid conditions. The quality and abundance of the following species improved: *Typha angustifolia*, *T. latifolia*, *Menyanthes trifoliata, Equisetum fluviatile, Urticularia intermedia, Lemna minor, Sparganium erectum, Calliergon giganteum*. In the first place this has resulted in rapid spread of *Typha* species, whose coverage has increased 10 times. The water level (water between tussocks was staying up to 30 cm above soil) did not exceed the upper limit of stability of the dominating species, which is *Carex elata*. That explains why the grass-stand production of this species was the highest at that time: 4 680 and 4 750 kg per ha.

In 2001 and 2002 a drought occurred, with the groundwater table dropping 10–30 cm below soil. This has resulted in opposite changes: the proportion of *Typha angustifolia*, *T. latifolia* has declined, while the presence of *Calamagrostis neglecta* and sedges has drastically increased. Low groundwater table has defined an overall decline in the production of upper-ground phytomass and disappearance of green mosses. Under lack of water green stalks of sedges managed to permeate through the old vegetation carpet some 15 days later than normal. The density of green stalks remained low.

The study included estimation of changes in the presence of willow shrubs and *Typha* species at open mires throughout the whole Plot I (60 ha). Thus, the area of shrubs has increased from 8% in 1995 to 15% in 2002, while the area of *Typha* species' stands increased from 3% to 6% over the same period. The increase in the area of shrubs occurs as a result of cessation of hay-cutting, while the spread of *Typha* species in the water-richest areas of the mire is defined by gradual but stable increase of the water level at the mire during most of the vegetation season in 1999. The increase in the area of *Typha* species was temporary and as the water level dropped in 2001 and 2002 the area of these species declined back to its normal proportion.

Table 2. Dynamics of most abundant plant species (projective coverage, in %) and production of Caricetum elatae communities at monitoring plot I.

Plant species	Indicator changes				
	1998	1999	2000	2001	2002
Phragmites australis	+	+	+	+	+
Typha angustifolia	1	5	6	7	8
Typha latifolia	-	3	5	4	5
Rumex hydrolapathum	+	2	+	1	+
Carex elata	83	80	81	83	85
Iris pseudacorus	+	3	1	2	1
Sparganium erectum	+	5	1	+	+
Calamagrostis neglecta	+	+	+	3	10
Equisetum fluviatile	10	15	25	10	5
Carex lasiocarpa	+	3	+	4	5
Ranunculus lingua	+	2	+	1	-
Carex diandra	+	1	+	1	1
Comarum palustre	1	9	12	3	5
Menyanthes trifoliata	40	30	35	25	20
Urticularia intermedia	20	30	+	1	2
Lemna trisulca	-	-	-	+	7
Lemna minor	15	10	-	-	+
Calliergon giganteum	10	7	+	-	-
Drepanocladus sendtneri	2	+	-	+	+
Drepanocladus aduncus	2	3	-	2	1
Bryum pseudotriquetrum	1	+	-	+	-
Cumulative projective coverage (%)	98	95	85	90	95
Exfoliation (coverage, %)	30	35	50	45	45
Production of the grass-stand (kg per ha)	4680	4750	3200	4300	4130
Water above soil (cm)	32	25	22	17	11

Dynamics of the density of Aquatic Warbler

The Aquatic Warbler population in the Yaselda river floodplain's Sporovskiy reserve is subject to significant fluctuations in density and number, especially at Plot I and Plot II (Table 6 and 7). Males' density at monitoring plots varied greatly in different years during first and second clutches. Proportion of males' densities during first and second clutches was as follow: at Plot I — 1: 0.58, at Plot II — 1:0.45, at Plot III — 1:1.14.

An old-time tradition of local people burning the previous year vegetation in early spring to increase hay-field productivity has still persisted in Byelarus'. Normally vegetation would be burnt upon completion of snow-melt, in March–April. In years when fires occurred when the water level at that time was below soil, the fire destroyed the upper peat layer, and new vegetation at the burned sites was very sparse as a consequence. Birds were occupying burned areas but with very low density: 25 and 21.4 males per km^2 respectively (Plot I, Table 3). Recovery of the Aquatic Warbler density began next year after the fire, gradually increasing in subsequent years as the

Table 3. Dynamics of Aquatic Warbler density (males per km²), and environmental factors at monitoring plots of Sporovskiy mire during first (15 May–20 June) and second clutch (1 July–25 July). Description of fire score — see Methods.

Plot	Parameter	Years															
		1996		1997		1998		1999		2000		2001		2002		2003	
		V–VI	VII	V–VI	VII	V–VI	VII	V–VI	VII	V–VI	VII	V–VI	VII	V–VI	VII	V–VI	VII
	Density	135	95	25	5	70,5	0	0	28	75,5	59,5	21,4	10	33	26,6	58,3	20
I	Water level, cm	9	14	-5	32	7	31	41	32	10	23	-39	-33	-16	-12	14	-25
	Fire, month	0		III (C)		0		0		0		IV (C)		0		0	
	Density	–	–	135	10	35	0	0	15	90	70	10	10	50	50	50	15
II	Water level, cm	–	–	0	28	-10	30	35	15	0	15	-30	-15	-10	-15	-10	-20
	Fire, month	0		0		III (B)		0		0		IV (C)		0		0	
	Density	–	–	–	–	40	95	0	20	115	85	85	64	100	120	75	90
III	Water level, cm	20	–	5	–	15	10	25	5	0	10	-10	-5	-5	5	0	0
	Fire, month	III		0		0		0		0		0		III (A)		IV (A)	

vegetation was restoring. When fires occur in low-water years the density of the species remains low during the second clutch, too. Such a pattern of fluctuation of the species' density under the impact of fires was noted at II and III Plots in 2003 (Table 3). The character of fires influence on Aquatic Warbler density is quite complicated: it is closely connected with water level fluctuations. This can explain the lack of correlation between fires and Aquatic Warbler density (r^2 = 0.20, r = 0.45, p = 0.042).

Impact of groundwater table

It was found that male density is closely related to water level at the mire during the breeding season. The density was highest in optimal water level is 0 to +10 cm. When the water level falls below or above those value a decline in males' density was observed (Fig. 1). Thus, males' density negatively correlates with rising of water level at the mire above soil surface (r^2 = 0.65, r = -0.81, p < 0.001). And there was correlation between declining of water level at the mire below soil surface and Aquatic Warbler density (r^2 = 0.58, r = 0.76, p < 0.001). Water rise over 20 cm above soil leads to inundation of potential breeding grounds, and birds abandon the inundated areas even amidst breeding. At Plot I and Plot II this is explained by absolutely flat relief of the area and absence of tussocks. Both summer rainfall events and prolonged spring floods have a negative impact on the state of the population.

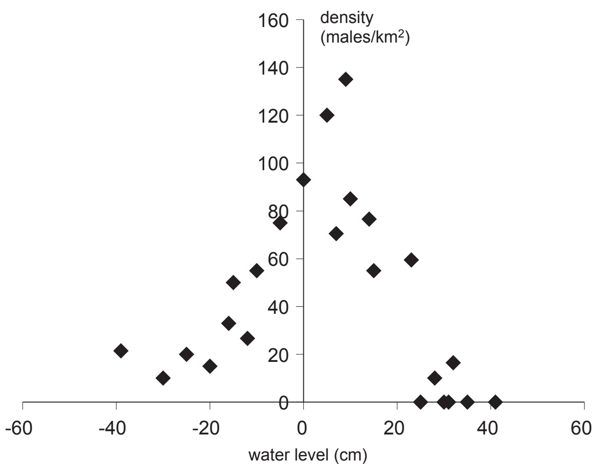

Fig. 1. Change of Aquatic Warbler male density at Sporovski mire depending on the water level (cm). 0 — ground level, +10 — water level above soil, -10 — water level below soil).

In two years (1998, 2000) summer rainfall floods started in late June–early July. The rising water inundated all clutches in 1998; in 2000 only late second clutches were inundated. Thus, in 1998 intensive rainfalls in early July resulted in a rise of water up to 20 cm above soil: all fresh second-clutch nests were inundated. Already 5 days after the inundation birds abandoned Plot I and Plot II and moved to other areas (Kozulin et al. 1999). In 1999 prolonged spring flood resulted in inundation of the whole floodplain up through mid-June. As of early May the water level at key breeding habitats within the floodplain was up to 50 cm. Birds were absent from all monitoring plots up to 26 June (Table 3). In late June water level dropped and first Aquatic Warblers appeared, however male density remained very low (10 males per km²). That year two nests of Aquatic Warbler were found, not on the ground but in the tangles of old sedge leaves some 25–30 cm above soil. This indicates of the capacity of the species to adapt to floods.

DISCUSSION

When the water level declines, the number of the species is falling too, the reason being the decline in the overall mire production, as well as poorer species composition and biomass of insects, especially those whose development is linked to presence of open water. Thus, in 2001 and 2002 the water level at the mire (Plots I and II) was significantly lower than normal (Table 3). This was the main reason why the number of the Aquatic Warbler in those years was low. Those mire parts which in 2001 remained safe from fire also had low density of the species. This can be attributed to lack of moisture and as a result to retarded development and low production of grass stands; at elevations grass vegetation did not develop at all. In the subsequent year 2002 water level remained low (10 cm below soil), which resulted in low production of phytomass and low density of Aquatic Warbler.

The male density in May (first clutch) is substantially different from that in July (second clutch). In stable favorable environment the density of males during the second-clutch breeding is somewhat lower than during the first clutch, which was the case at Plot I in 1996, and at Plot III in 2000. In all other years the density of males was different during the second clutch specifically because of the changes in the water table. In years when the water level drastically increased in July birds left the sites for other areas more favorable breeding conditions. This was observed in 1998 when a rise in the water level resulted in birds abandoning one of the mires (Plot I and II sites) and moving to a new area, with a correspondingly high increase of density there (at Plot III, see Table 3). In some cases increased male density in July compared to May is attributed, probably, to the improvement of breeding conditions during the second-clutch breeding. Thus, an increase in the density of males at Plot III in July of 2002 may be attributed to a rise in the water level. In 2003 the breeding conditions at Plot III during the first clutch were unfavorable because all old grass (used by birds to hide their nests) had been destroyed by the fire. In July the newly developed sedge was high enough for birds to hide the nests, which, presumably, was the reason behind a higher density of males during the second clutch.

The overall number of the Aquatic Warbler in the last 40 years was, probably, falling at Sporovskiy reserve as a result of diminishing area of open fens. Successions are brought about both by natural processes as well as by changes in the hydrological regime of the surrounding areas and decline of traditional non-intensive forms of mire use.

The main factors defining the present-day changes in the number of Aquatic Warbler at Sporovskiy mire are extreme fluctuations of the water table at mires leading to floods or droughts, as well as fires. In most cases floods, droughts and fires on mires are linked to hydrological changes brought about by anthropogenic factors. Impact of floods on numbers of Aquatic Warbler depends on the scale of water rise, timing of the flood and local mire relief. The relief of Yaselda river floodplain is low-lying and very flat, which means that the upper ground is easily flooded when water in the Yaselda river rises by 20–50 cm above the floodplain. If the high water occurs from the time of birds' arrival till the beginning of breeding, Aquatic Warblers do not start breeding at all. If the water rises in the midst of breeding, birds abandon flooded areas and move to the neighboring water-free areas (Kozulin et al. 1999). Fluctuations of the water level in the river and in the floodplain are brought about by prolonged rainfalls and especially by the operations of the Selets water reservoir constructed upstream of the monitoring site.

Study of breeding ecology of Aquatic Warbler at Plot I monitoring plot and comparison of breeding success with water level allow us to

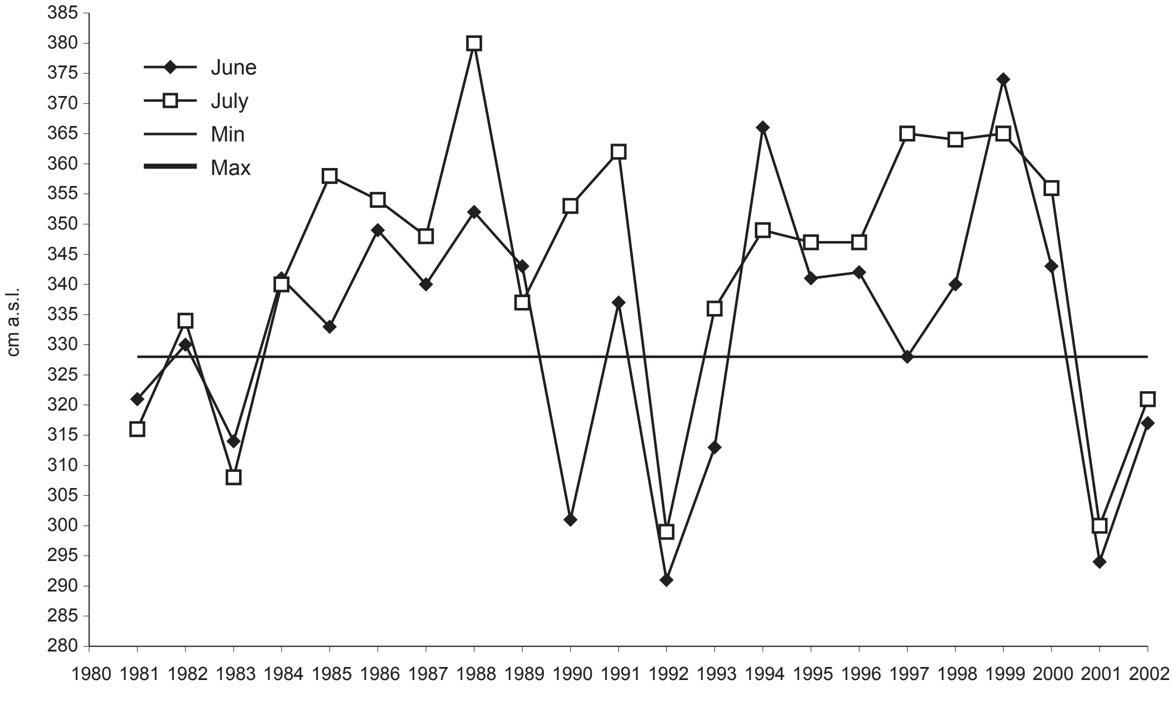

Fig. 2. Water level dynamics on 1 June and 1 July from 1981 through 2002 at monitoring plot I. The minimum and maximum curves indicate the lower and upper limits of water level fluctuations within which conditions for breeding of Aquatic Warbler remain favorable. 345 cm above sea corresponds to 12 cm above soil, while 328 cm above sea corresponds to 5 cm below soil.

extrapolate data obtained to prolonged period. Successful breeding of Aquatic Warbler occurs when the groundwater table coincides with the upper soil level; permissible fluctuations of the optimal water table are in the range of 12 cm above soil to 5 cm below soil, which corresponds to absolute altitudes of 328 through 345 m above sea. Aquatic Warbler is very special about these conditions because the relief of the mire is very flat and even insignificant rise of the water level results in inundation of nests, while extremely dry years, on the other hand, are accompanied by a substantial decline in the density of water insects. Fig. 2 shows the level of the water in the Yaselda river floodplain on 1 June and 1 July from 1981 through 2002. Comparison of data on the density of males and water level within this period makes it possible to count the number of favorable and unfavorable years for breeding of Aquatic Warbler. Thus, the number of years with successful first-clutch breeding of the species (data for 1 June) was 11 years (47.8%). The number of years with successful second clutches was only 4 years (17.3%). The number of years when both the first and the second clutches were unsuccessful was 9 (39%). Impact of drought on the populations of the species has been insufficiently studied. If the dry year follows a normal one (with no fires), the density of males and the breeding success do not change substantially. However, if two dry years follow each other in a row, than the number of males in the second year decreases slightly, but the density of nests drops by more than 50% (from 25 nests per km² in normal years to 10 nests in the second dry year, which was the case at the Plot I and Plot II monitoring plots in 2001 and 2002, Table 3). Additionally, severe droughts frequently contribute to start and spread of fires. Declining bird numbers under dry conditions are attributed to the overall decline in vegetation production, poorer species composition and biomass of insects, especially those whose development is linked to presence of open water.

Impact of fires on the numbers of breeding birds depends on the timing of the fire and the groundwater level in the mire at the time of the fire. When the water table at the mire drops substantially, which is often the outcome of operation of water using facilities in a manner, which violates the established protection regime at reserve, fires can spread over significant areas. As a result the upper peat layer burns out and vegetation does not develop at all, which means that large mire areas become absolutely inappropriate for breeding. Additionally, recovery of Aquatic Warbler density on formerly burned areas is occurring gradually: the density can reach 50% of its potential over one year and only two years after the fire the density can be restored fully. This is explained by the fact that fires bring significant damage to the feeding base and the sheltering conditions: fire destroys insects and old sedge where birds mask their nests. However, if the water level during the fire is some 20–30 cm above soil, only reeds and upper parts of dry sedges get destroyed: this only improves the breeding conditions of the Aquatic Warbler because the density of dry reed stalks falls down, accompanied by a corresponding increase in the production of sedges.

Taking into consideration that water level fluctuations and fires are quite common at fen mires, Aquatic Warbler should has adaptations to these factors. We have recorded following adaptations to changing environmental conditions:

— can move from one place to another more favorable mire plots (up to 30 km) even during breeding season (Kozulin et al. 1999);

— change breeding terms — under unfavorable conditions most females can breed not in May, but in July, which is confirmed by increasing of males' density in July compared with May (Table 3);

— females were able to construct nests in not typical places: in rectangles of old vegetation over the water – when the water level is high; without cover of dry vegetation (in tussocks, among green sedge leaves) — after spring fires.

These adaptations allow species to survive during unfavorable years with minimal losses. However if years with floods, droughts and fires occur too often and follow each other, adaptations could be insufficient to support the species number on optimal level.

Thus, the ecologically potential density of the Aquatic Warbler in Sporovskiy reserve is 135 males per km², but the density cannot reach its maximum owing to extremely unstable environmental conditions.

The overall population size (number of males in May) at Sporovskiy reserve fluctuates from 2515 males in favorable years to 0 during unfavorable years (Fig. 3). Trend of numbers can be characterized as greatly fluctuated with insignificant lowering (R^2 = 0.012). The pattern of the changes in the population size and — more importantly — the data on the recovery of the population size upon unfavorable years indicate that the key factor defining the overall population size, are

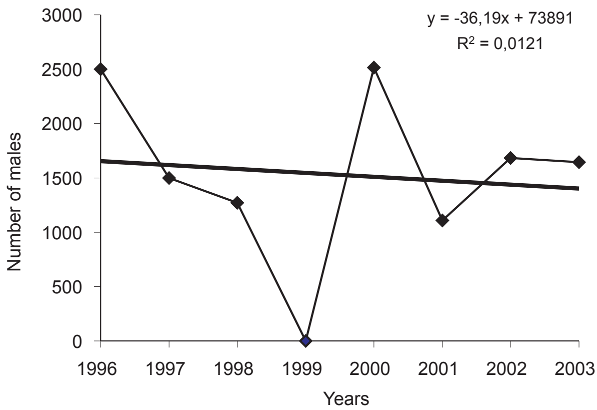

Fig. 3. Dynamics of the number of Aquatic Warbler at Sporovskiy mire.

Table 4. Aquatic Warbler density (males per km²), at monitoring plots of Sporovskiy mire during first (15 May–20 June) and second clutch (1 July–25 July).

Plots (seasons)	Mean ± SD (range)	
	V–VI	VIII
I (1996–2003)	52.3 ± 14.97 (0–135)	30.5 ± 11.29 (0–95)
II (1997–2003)	52.9 ± 17.66 (0–135)	24.3 ± 9.66 (0–70)
III (1998–2003)	69.2 ± 17.29 (0–115)	79.0 ± 13.9 (20–120)

not migration/wintering conditions, but rather the state of breeding biotopes. If the hydrological regime in the mire remained optimal several years in a row, then the population size of the species would recover to its carrying capacity, which for this habitat would mount to about 3 000 males.

Thus, despite the overall stable condition of Aquatic Warbler at Sporovskiy reserve, the size of the population fluctuated significantly among years, which was defined by various factors. And since the main part of the Byelarussian population of Aquatic Warbler is concentrated only at a limited number of mires, unstable breeding conditions at key mires puts the species at risk. In the past suitable habitat area for the species was very large and when unfavorable conditions occurred at one of the mire the overall population was supported by other mires. Recently over 90% of the Byelarussian population of the species breeds just at 3 mires, and prolonged unfavorable conditions retained over several subsequent years even at one of these key habitats may result in dramatic consequences. In view of the above, the present-day strategy for species conservation should be based on active management of those fen mires that managed to remain natural.

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STRESZCZENIE

[Czynniki wpływające na zmiany liczebności wodniczki]

Badania prowadzono na trzech powierzchniach położonych w obrębie rezerwatu "Sporovskoye" (dolina rz. Jaseldy, Białoruś) w latach 1996–2003.

Zagęszczenia śpiewających samców na poszczególnych powierzchniach badań znacznie różniła się w poszczególnych latach, różnice obserwowano także porównując zagęszczenia samców w okresie pierwszych i drugich lęgów. Proporcja samców na powierzchni I ("Peschanka") wynosiła 1:0.58, na powierzchni II ("Kostyuki") — 1: 0.45, na III ("Kokoritsa") — 1:1.14.

Podstawowymi czynnikami wpływającymi na zmiany zagęszczenia samców wodniczki były zmiany poziomu wody i wypalanie roślinności. Stwierdzono istotną statystycznie zależność między poziomem wody ponad poziom gruntu a zagęszczeniem samców (R^2 = 0.65, r = -0.81,

p < 0.001). Efekt oddziaływania podwyższenia lustra wody zależy od czasu, w jakim ma miejsce i ukształtowania terenu. Teren badań był płaski, stąd też podwyższenia poziomu wody do 20–50 cm powyżej gruntu uniemożliwiało wodniczkom gniazdowanie. Obniżenie poziomu lustra wody poniżej poziomu gruntu także pociąga za sobą zmniejszenie zagęszczenia samców wodniczki (R^2 = 0.58, r = 0.76, $p < 0.001$). W takich przypadkach zmniejszenia zagęszczeń wodniczki powodowane jest zubożeniem składu gatunkowego owadów i zmniejszeniem ich liczebności. Zdecydowanie negatywne skutki na liczebność wodniczki miały trwające kilka lat okresy niskiego poziomu wody.

Negatywny wpływ na bytowanie gatunku miało także wiosenne wypalanie traw praktykowane przez miejscową ludność. Wpływ ten zależy od poziomu wody. W latach wysokiego poziomu lustra wody wypalanie może nawet odgrywać pozytywną rolę (niszczenie zakrzaczeń), podczas lat suchych — negatywną (brak owadów, starych traw wykorzystywanych do maskowania gniazd).