WATER LEVEL DECREASE AND ITS EFFECTS ON THE BREEDING BIRD COMMUNITY IN A REMNANT WETLAND IN CENTRAL ITALY

CORRADO BATTISTI[1], CRISTINA AGLITTI[1], ALBERTO SORACE[2], MARCO TROTTA[3]

[1] Environmental Service, Province of Rome, Via Tiburtina, 691, 00159 Roma, Italy, e-mail: cbattisti@inwind.it
[2] Laboratory Compared Tossicology and Ecotossicology, National Institute of Health, Viale Regina Elena 299, 00161 Roma, Italy
[3] Stazione Romana Osservazione e Protezione Uccelli, c/o Lynx, Via Britannia, 36, 00183 Roma, Italy

Abstract

Battisti C., Aglitti C., Sorace A., Trotta M.: Water level decrease and its effects on the breeding bird community in a remnant wetland in Central Italy. Ekológia (Bratislava), Vol. 25, No. 3, p. 262–263, 2006.

The reduction of wetlands is an important cause of conservation concern since some specialist, vulnerable and rare species live in these habitats. Although several investigations on bird communities of fragmented wetland have been carried out, studies on the effects of specific disturbance factors on bird populations and communities of wetland are scarce. In this study the effects of water level oscillation on bird populations of a wetland were investigated. Bird communities were monitored by means of mapping census method in the wetland and surrounding open habitats of a Central Italy study area for two consecutive breeding seasons (2001 and 2002 springs). In the second year the reduction of rainfall dramatically lowered the water level. Species richness, diversity, abundance, and biomass values decreased from 2001 to 2002. This was related to the significant reduction of density of the bird species associated to the reedbed and wet habitats. Except for *Anas platyrhynchos* and *Acrocephalus scirpaceus*, all species of reedbed and aquatic habitats were absent in the spring 2002. Change in richness and in relative frequency of the species in two years, due to disturbance induced by the water level oscillations, were highlighted by diversity/dominance diagram.

The results suggest that conservation actions for remnant wetlands should take into account the problems related to the water cycles at multiple scales.

Key words: habitat fragmentation, remnant wetlands, rainfall, water level oscillations, reedbed, breeding birds

Introduction

In anthropized mosaic landscape, wetlands can assume remnant characteristics (Williams, 1991). Their limited size, reduced habitat diversity, high isolation and edge effect are factors affecting several taxa (Tscharntke, 1992; Báldi, Kisbenedek, 1998; Báldi, 1999). Moreover, the anthropic matrix surrounding these fragments can markedly influence intra-fragment processes that can be under the complete control of external, stochastic, inter-fragment factors (Harris, Silva Lopez, 1992). In particular, irrigation, water storage or drainage in the surroundings may affect remnant areas of natural wetlands in fragmented landscapes (Saunders et al., 1991). Water level oscillations, following reduced rainfall, may represent a further stochastic catastrophic disturbance affecting status and dynamics of sensitive species living in such remnant ecosystems (Farina, 2001).

Studies on the effects of specific disturbance factors on bird populations and communities of wetlands in fragmented landscapes are limited (Graveland, 1998; Barbraud et al., 2002). In our study area, a coastal wetland, the clear reduction of rainfall dramatically reduced the water level in winter 2001–2002 as compared to the previous year. This natural phenomenon allowed the evaluation of the effects of water level changes on bird community in a remnant wetland. Such investigation may provide relevant information for the environmental management and restoring of a protected coastal wetland at fragment scale.

Material and methods

Study area is found inside the "Palude di Torre Flavia" Natural Monument (Central Italy; 41°58' N; 12°03' E), a small protected wetland (40 ha) on the Tyrrhenian coast (Zone of Special Protection according to the European Directive 79/409/CEE). It is a relict of a larger wetland, recently drained and transformed.

At landscape scale, this area shows characteristics of a remnant fragment of wetland inside an agricultural and urbanized matrix. At the study scale, it shows a specific, seminatural patchiness with water collections and channels (utilized in the years before the study, for mullets, *Mugil cephalus*, breeding), reedbeds (*Phragmites australis*), flooded meadows, dune and backdune areas, patches with *Carex hirta, Juncus acutus* and Cyperaceae.

The water in the wet area is mainly of meteoric and seastorm origin (mesomediterranean xeric region; Tomaselli et al., 1973). Depth is variable in time and no water is present in the period June–October. Flow from surrounding areas is scarce.

The two study years have been characterized by different pluviometric regimes with scarcer rains in winter 2002 (Fig. 1). Such difference strongly affected water level in the swamp (more than 1 m in winter 2001 *vs*. 40–60 cm in winter 2002 with broad, dried portions in the study area).

In two consecutive years, in 11 ha area (about 6 ha within the reedbed and about 5 ha within open habitats) bird communities were monitored by means of mapping census method (Bibby et al., 2000), carrying out 18 visits from 16 March to 8 July 2001 (about 26 hours of observations) and 14 visits from 20 March to 3 July 2002 (about 23 hours of observations). Contacts were transcribed on a local map (1: 2 000). One point was given to territories completely inside the study area and 0.5 point to edge territories.

For the bird communities, the following breeding parameters were calculated:

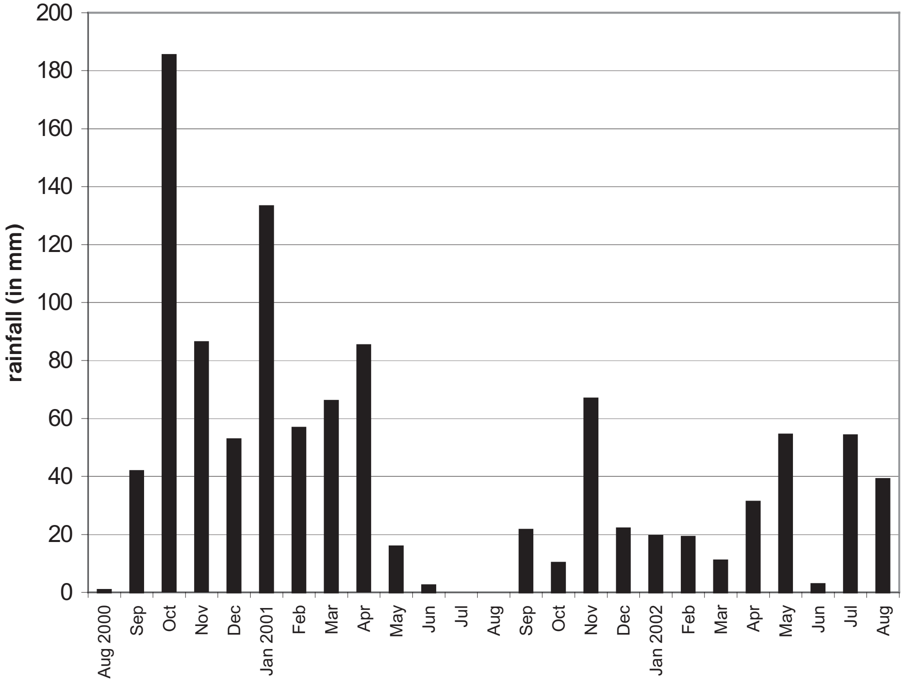

Fig. 1. Rainfall (in mm) in the two study years (total values subdivided in decades). Source: Central Office of Agricultural Ecology of Rome (Palo Laziale station, 5 km from study area).

Richness (S); Total Abundance (Tot Ab; total number of pairs); relative frequency for each species (fi; dominant species: fi > 0.05; Turček, 1956); Density (d; expressed in pairs/10 ha); Ecological Density (ed; referred to species density in the most used habitat: Ph: species mainly found in the reedbed: *Phragmitetum*; Oh: species found in the open habitats: flooded and edge areas, dune and backdune areas); Diversity (H; Shannon, Weaver, 1963); Eveness (J = H/Hmax; Lloyd, Ghelardi, 1964; where Hmax = log S; Pielou, 1966); % non Passeriformes (% non Pass.); *Phragmitetum*-linked species/Richness ratio (Ph/S); Open habitat-linked species/Richness ratio (Oh/S); Standing crop biomass (Scb; the total body mass of all censused individuals in g/10 ha); Consuming biomass (Cb; in g/10 ha; calculated as: $Cb = Scb^{0.7}$; Salt, 1957).

To calculate the biomass values, mean body mass values for *Tachybaptus ruficollis, Anas platyrhynchos, Gallinula chloropus, Fulica atra, Charadrius dubius,* and *Galerida cristata* were obtained by BWP volumes (Cramp, Simmons, 1977, 1980, 1983; Cramp, 1988), mean body mass of *Ixobrychus minutus, Motacilla alba, Serinus serinus, Carduelis carduelis,* and *Miliaria calandra* were obtained by the body mass of individuals of these species captured in Central Italy (Gustin, Sorace, 1999, 2001), and mean body mass of the other recorded species was obtained by the data archive of the local ringing station.

Due to the limited vocalizations of *Tachybaptus ruficollis*, *Anas platyrhynchos, Gallinula chloropus, Fulica atra* and *Rallus aquaticus*, an estimated value of the density of such species was drawn from the counting of the observed individuals (Lambertini, 1987). Species that utilize the study area only for foraging or roosting (e.g. *Hirundo rustica, Pica pica, Corvus corone cornix, Sturnus vulgaris, Passer italiae*) were not counted.

A diversity/dominance analysis (Whittaker, 1965) was carried out (species rank/relative frequency diagram). This analysis may highlight the effects of natural/anthropic disturbance on the communities (e.g. changes in richness, dominance, frequency; see Begon et al., 1986).

In each study year, to evaluate the *Phragmitetum* structure, several 0.25 m^2 samplings were randomly chosen throughout the 11 ha study reedbed (24 squares in the first study year, 2001, and 22 in the second study year, 2002). In each square the diameter of stems was measured at breast height (1.40 m) and the number of stems was counted (stem density = number of stems/0.25 m^2; Table 1; see Bernoni, 1984). Z test was used to compare the differences between the two study years for the stem diameter while T test for independent samples was used to compare the stem density. Tests were conducted after checking for the normality of the variables (Kolmogorov-Smirnov test) and for the homogeneity of the variances (Fowler, Cohen, 1992). Due to the small sample of several comparisons, non-parametric Wilcoxon test was performed to evaluate the statistical significance of the differences between the two study years for both the density and biomass of the recorded bird species.

Results

The reedbed structure shows no significant differences between the two study years both for the mean diameter of reeds ($z_{1276.1029} = 1.018$; $p > 0.05$) and for the stem density ($T = 0.84$; d.f. = 44; $p = 0.41$; Table 1).

T a b l e 1. Reedbed structure in the two study years.

	Squares	N	Mean diameter (± SD)	Range	Stems/0.25 m^2 (± SD)	Range
I year (2001)	24	1277	0.44 (± 0.24)	0.06–1.55	53.2 (± 16.97)	23–76
II year (2002)	22	1030	0.43 (± 0.23)	0.07–1.60	46.8 (± 33.01)	11–147

The number of 0.25 m^2 randomly selected squares in the reedbeds is reported. Total number (N), mean diameter (in cm, with standard deviation, SD, and range values) and density of stems (stem number/0.25 m^2 with SD and range values) are shown. No significant differences between the two study years were observed (see Results).

In the first spring, 17 breeding species were recorded. In the following year the number decreased to 11 species, because *Tachybaptus ruficollis, Ixobrychus minutus, Gallinula chloropus, Fulica atra, Acrocephalus arundinaceus, Serinus serinus* were not observed.

T a b l e 2. Breeding species recorded in the two study years.

	2001					2002				
Species	d	fi	ed	Scb	Cb	d	fi	ed	Scb	Cb
Tachybaptus ruficollis	3.64	**0.100**	6.67 (Ph)	1572.5	172.8					
Ixobrychus minutus	0.91	0.025	1.67 (Ph)	156.3	34.3					
Anas platyrhynchos	2.73	**0.075**	5.00 (Ph)	6270.8	455.1	1.82	**0.076**	3.33 (Ph)	4180.5	342.7
Gallinula chloropus	3.64	**0.100**	6.67 (Ph)	2326.0	227.3					
Fulica atra	1.82	**0.050**	3.33 (Ph)	3050.3	274.8					
Charadrius dubius	0.91	0.025	2.00 (Oh)	72.8	20.1	0.45	0.019	1.00 (Oh)	36.0	12.3
Galerida cristata	0.91	0.025	2.00 (Oh)	81.0	21.7	1.36	**0.057**	3.00 (Oh)	121.0	28.7
Motacilla alba	0.45	0.012	1.00 (Oh)	17.5	7.4	0.91	0.038	2.00 (Oh)	35.3	12.1
Saxicola torquata	0.91	0.025	2.00 (Oh)	26.0	9.8	0.45	0.019	1.00 (Oh)	12.9	6.0
Cettia cetti	1.36	0.037	2.50 (Ph)	32.6	11.5	0.91	0.038	1.67 (Ph)	21.8	8.7
Cisticola juncidis	6.36	**0.175**	14.00 (Oh)	122.1	28.9	5.91	**0.246**	13.00 (Oh)	113.5	27.4
Acrocephalus scirpaceus	9.55	**0.263**	17.50 (Ph)	208.2	42.0	9.09	**0.378**	16.67 (Ph)	198.2	40.5
Acrocephalus arundinaceus	0.91	0.025	1.67 (Ph)	55.1	16.6					
Serinus serinus	0.45	0.012	1.00 (Oh)	10.0	5.0					
Carduelis chloris	0.45	0.012	1.00 (Oh)	22.3	8.8	0.45	0.019	1.00 (Oh)	22.3	8.8
Carduelis carduelis	0.45	0.012	1.00 (Oh)	14.4	6.5	0.45	0.019	1.00 (Oh)	14.4	6.5
Miliaria calandra	0.91	0.025	2.00 (Oh)	77.7	21.0	2.27	**0.094**	5.00 (Oh)	193.9	39.9

Density (d: pairs/10 ha), relative frequency (fi), ecological density (d. ecol.: Ph: *Phragmitetum*-linked species; Oh: open habitat-linked species; see methods); Standing crop biomass (Scb; in g); Consuming biomass (Cb; in g). Dominant species in bold (fi > 0.05).

Anas platyrhynchos, Charadrius dubius, Galerida cristata, *Motacilla alba, Saxicola torquata, Cettia cetti, Cisticola juncidis, Acrocephalus scirpaceus, Carduelis chloris, C. carduelis, Miliaria calandra* were observed in both years (Table 2). Among them, *Anas platyrhynchos, Cisticola juncidis,* and *Acrocephalus scirpaceus* were dominant in both years. Sporadic observations were carried out for *Rallus aquaticus* in the first study year, and for *Ixobrychus minutus, Acrocephalus arundinaceus, Sylvia melanocephala, Remiz pendulinus* in the second study year.

The values of bird community parameters decreased from 2001 to 2002 (Fig. 2, Table 3 and 4). The *Phragmitetum*-linked species/Richness ratio decrease and the Open habitat-linked species/Richness ratio increase in 2002 respect to 2001 (Table 4).

A clear decrease in the second study year of the abundance of the species associated to the *Phragmitetum* and aquatic habitats (Table 2 and 3) is shown. In particular, except *Anas platyrhynchos* and *Acrocephalus scirpaceus*, all species exclusive of reedbed and aquatic habitats were absent in the spring 2002. As a consequence, a significant reduction of biomass was recorded in the second study year (Fig. 2, Table 3 and 4).

Species rank/relative frequency diagram show a steeper slope in 2002 (Fig. 3).

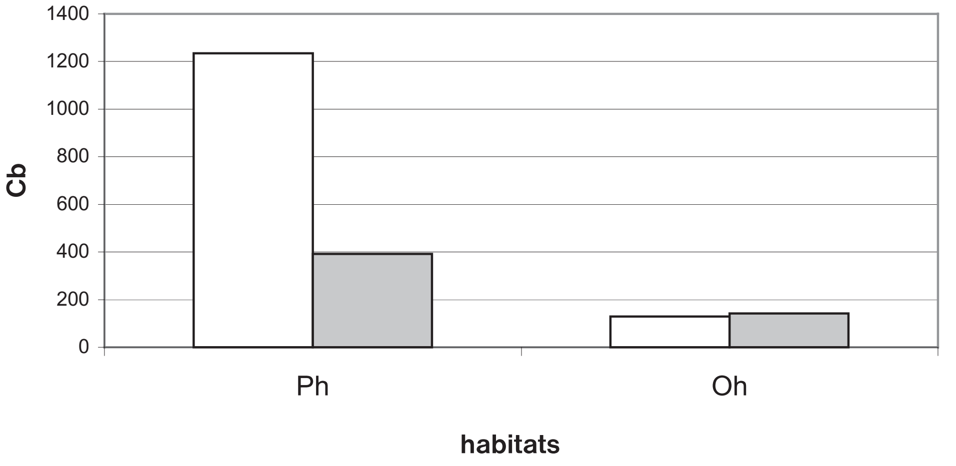

Fig. 2. Consuming biomass values (Cb, in g) recorded in the two study years (white: 2001; grey: 2002) for the breeding bird species of the two study habitats (Ph: *Phragmitetum*-linked species; Oh: open habitat-linked species; see methods). Cb = $Scb^{0.7}$, where Scb (Standing crop biomass) is the sum of the body mass of all recorded species.

T a b l e 3. Mean values (and standard deviation) of density and biomass obtained for the censused bird species in the two study years.

	2001	2002	Statistical significance
d	2.1 ± 2.5	1.4 ± 2.5	Z = 2.24, N = 17, p = **0.02**
Scb	830.3 ± 1675.1	291.2 ± 1004.5	Z = 2.04, N = 17, p = **0.04**
Cb	80.2 ± 127.6	31.4 ± 81.4	Z = 2.16, N = 17, p = **0.03**
d (Ph)	3.1 ± 2.8	1.5 ± 3.1	Z = 2.52, N = 8, p = **0.01**
ed (Ph)	5.6 ± 5.2	2.7 ± 5.8	Z = 2.52, N = 8, p = **0.01**
Scb (Ph)	1709.0 ± 2178.4	550.1 ± 1468.5	Z = 2.52, N = 8, p = **0.01**
Cb (Ph)	154.3 ± 159.0	49.0 ± 119.5	Z = 2.52, N = 8, p = **0.01**
d (Oh)	1.3 ± 1.9	1.4 ± 1.8	Z = 0.08, N = 9, p = 0.9
ed (Oh)	2.9 ± 4.2	3.0 ± 4.0	Z = 0.0, N = 9, p = 1.0
Scb (Oh)	49.3 ± 39.9	61.0 ± 66.1	Z = 0.5, N = 9, p = 0.6
Cb (Oh)	14.3 ± 8.6	15.7 ± 13.2	Z = 0.2, N = 9, p = 0.9

Density (d), ecological density (ed), Standing crop biomass (Scb; in g), and Consuming biomass (Cb; in g) are indicated. Ph: *Phragmitetum*-linked species; Oh: open habitat-linked species (see methods). Statistical significance of the comparisons between the two study years is also reported (significant values in bold; Wilcoxon test).

T a b l e 4. Structural parameters of the bird community in the two study years.

Year	2001		2002	
S	17	8 (Ph), 9 (Oh)	11	3 (Ph), 8 (Oh)
Tot ab	40	27 (Ph), 13 (Oh)	26.5	13 (Ph), 13.5 (Oh)
D tot (c/10 ha)	36.36		24.07	
H	2.36	1.77 (Ph), 1.62 (Oh)	1.84	0.69 (Ph), 1.59 (Oh)
J	0.83	0.85 (Ph), 0.74 (Oh)	0.77	0.63 (Ph), 0.76 (Oh)
Ph/S	0.47		0.27	
Oh/S	0.53		0.73	
% non Pass.	35.3	62.5 (Ph), 11.1 (Oh)	18.2	33.3 (Ph), 12.5 (Oh)
Scb	14115.7	13671.88 (Ph), 443.82 (Oh)	4949.81	4400.54 (Ph), 549.27 (Oh)
Cb	1363.61	1234.42 (Ph), 129.19 (Oh)	533.59	391.86 (Ph), 141.73 (Oh)

Species richness (S); Total abundance (Tot ab; total n. of pairs of overall bird species); Total density (D tot; total n. of pairs/10 ha of overall bird species); Shannon Diversity (H); Evenness (J); percentage of non Passeriformes species (% non Pass.); *Phragmitetum*-linked/Richness ratio (Ph/S); Open habitat-linked species/Richness ratio (Oh/S); Standing crop biomass (Scb); Consuming biomass (Cb) (Ph: *Phragmitetum*-linked species; Oh: Open habitat-linked species, see methods).

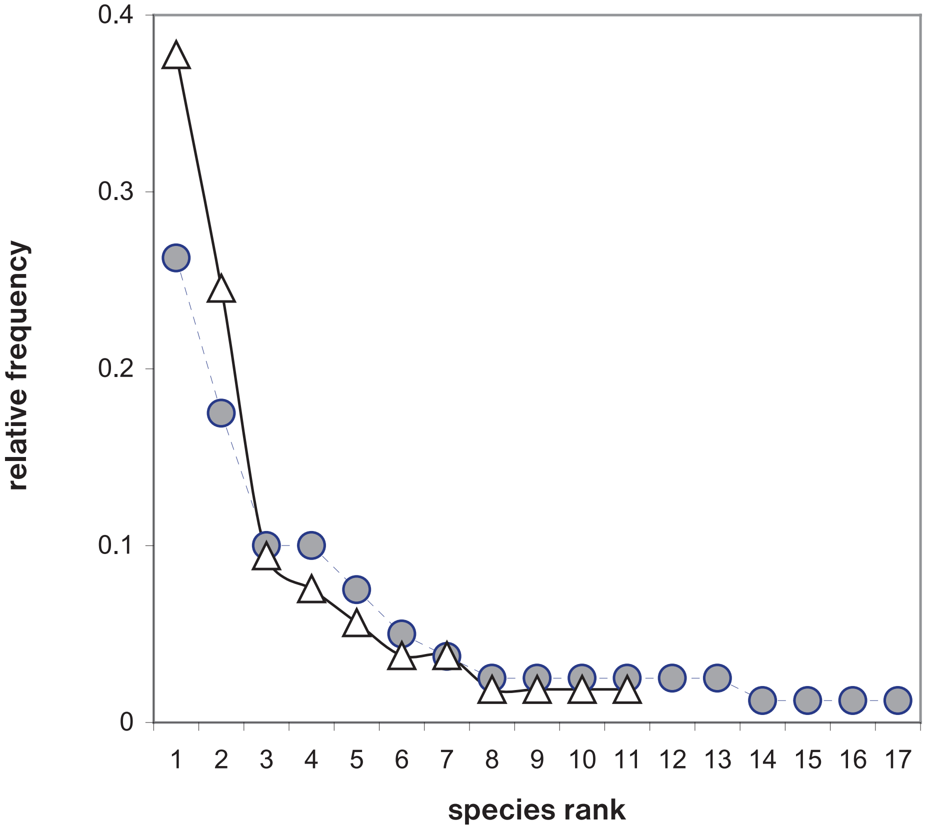

Fig. 3. Species rank/relative frequency diagram (see Methods). Triangles: 2002; Circles: 2001. The steeper slope of the curve indicate disturbance (see Discussion).

Discussion

The scarce rains in the winter 2001–2002 and the consequent reduction of water level greatly affected the breeding bird community parameters in the wet area. These changes are not due to differences in some parameters of size/quality of the *Phragmitetum* (not significant in values of density and diameter of the stems between years).

Species richness, total abundance, and other community parameters (e.g. *Phragmitetum*-linked species/Richness ratio) underwent a strong reduction in the second year. The structural changes in communities were evident also showing the species rank/relative frequency diagram. The steeper slope of the curve in 2002 highlights the change of the dominance values of some species due, in part, to decrease in species richness. Change in shape of diversity/dominance curves suggests the presence of disturbances (see Begon et al., 1986).

The guilds of species linked to the reedbed and wetland were particularly affected and the species that needed a suitable water level disappeared. In the second study year, a drastic significant decrease of the total biomass was found also due to the fact that the disappeared species more strictly linked to acquatic habitats and to the reedbed (e.g. Anatidae and Rallidae) have a higher mean body mass.

Some generalist species are always present (e.g. *Motacilla alba, Carduelis chloris, C. carduelis*; edge species, see Møller, 1987; McCollin, 1993) influencing the structural patterns observed.

In wetland remnants, environmental stress, such as natural (e.g. scarce rains) and anthropogenic (e.g. water uptake for irrigation) water level changes, may be a threat for sensitive populations along with the reduced size and isolation, edge effect, and others factors (competition with generalist species, anthropic disturbance). This may be particularly true for many Mediterranean areas where, due to the excessive water catching and recent climatic changes, the hydrologic balance is source of concern (Blondel, Aronson, 1999). Several authors reported the negative effects of fluctuations of water levels on some sensitive bird species living in such areas (e.g. limited to the Italian territory, Calvario, Sarrocco, 1995 for *Tachybaptus ruficollis*; Pezzo, Benocci, 2001 for *Ixobrychus minutus*; Campedelli, Tellini Florenzano, 2001 for *Fulica atra*). Moreover, it has to be pointed out that a reduced water level might also promote the access to reedbed for the terrestrial predators increasing the impact on breeding bird clutches (Catchpole, 1974; Thomas et al., 1999). This might lead some species to avoid reedbeds surrounded by low level (or absence) of water. After all, water level oscillations induce also changes in size of the wetland habitat for *Phragmitetum*-linked species (e.g. *Tachybaptus ruficollis* and *Fulica atra*, area-sensitive species; Celada, Bogliani, 1993; McCollin, 1993).

As far as the species more strictly living in the reedbed are concerned, it is noteworthy that although *Acrocephalus scirpaceus* has a higher sensitivity to the edge and area effect than *A. arundinaceus* (Opdam et al., 1994; Báldi, Kisbenedek, 1999; Moskát, Báldi, 1999), in the present study the densities of *A. scirpaceus* in reedbed do not seem to be clearly affected by the reduced quality (e.g. water level oscillations) and (consequently) size of the habitat. This can be due to the fact that, in spite of the *A. scirpaceus* preference for aquatic habitats (Catchpole, 1973), it can breed successfully also in dry land (Catchpole, 1974). Conversely, *A. arundinaceus* seemed sensitive to a reduction of aquatic levels (Leisler, 1981; Graveland, 1998 and present study).

Our results suggest that conservation strategy on remnant wetlands should focus on the problems related to the water cycles (e.g. water level control), applying management techniques mainly directed to controlling the deterministic/stochastic external factors that act on water resources and that often do it at a scale wider (e.g. landscape) than the fragment one (e.g. pumping systems to retain adequate water levels; Saunders et al., 1991).

Preservation of high-quality habitats (e.g. with suitable water level), even in small wetland fragments, has a high priority for the conservation of *Acrocephalus* warblers and other habitat specialists (Haila, 1985). Moreover, an enlargement of the areas covered by *Phragmitetum* might be beneficial since most species found in the open habitat of the study area are common and widespread in the Italian territory (Meschini, Frugis, 1993) whereas large reedbeds may promote the presence of species of conservation concern such as purple heron *Ardea purpurea*, European bittern *Botaurus stellaris* and marsh harrier *Circus aeruginosus* (Hagemeijer, Blair, 1997; Tyler et al., 1998; Barbraud et al., 2002).

This study could be expanded on wider spatial and temporal scale to demonstrate if patterns persist, allowing to evaluate the role played by climatic factors as disturbance on structure of bird populations and communities in remnant wet ecosystems.

Translated by the authors

Acknowledgement

This study has been performed within the activities of the Environmental Service – Province of Rome, that manages 'Torre Flavia' protected area. We would like to acknowledge E. De Angelis, C. Galimberti, N. Trucchia, specialized environmental operators in the study area for the help in assessing reedbed structure. A special thank to J. Cecere, M. Gustin, S. Laurenti, P. Monti, E. Savo, and A. Duiz from the local ringing station; A. Zocchi for English revision. The Central Office of Agricultural Ecology of Rome (Maria Carmen Beltrano) has kindly given pluviometric data.

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Received 4. 5. 2004

Battisti C., Aglitti C., Sorace A., Trotta M.: **Pokles hladiny vody a jeho vplyv na spoločenstvá hniezdiacich vtákov na zvyšku mokrade v strednom Taliansku.**

Úbytok mokradí je dôležitou príčinou ochrany, keďže v týchto biotopoch žijú hodnotné a zriedkavé druhy. Hoci boli niektoré výskumy u vtáčích spoločenstiev uskutočnené na zvyšku mokradí, štúdie o vplyvoch špecifických rušivých faktorov na vtáčie populácie a spoločenstvá na mokradiach sú zriedkavé. Táto štúdia skúma vplyvy výkyvov vodnej hladiny na populáciu vtákov v mokradi. Vtáčie spoločenstvá sme monitorovali pomocou metódy mapového sčítania v mokradi a okolitých otvorených biotopoch v Strednom Taliansku počas dvoch hniezdiacich obdobiach (jar 2001 a 2002). V druhom roku pokles zrážok dramaticky znížil hladinu vody. Od roku 2001 sa znížilo druhové bohatstvo, diverzita, abundancia a hodnoty biomasy. Súviselo to s významnou redukciou hustoty druhov vtákov viazaných na rákosový porast a mokrý biotop. Na jar 2002 chýbali okrem *Anas platyrhynchos* a *Acrocephalus scripaceus* všetky druhy rákosových a mokrých biotopov. Zmeny v bohatstve a relatívnej abundancii druhov počas dvoch rokov v dôsledku kolísania vodnej hladiny sme zdôraznili na diagramoch diverzity/dominancie. Výsledky štúdie naznačujú, že by ochranné práce na zvyškoch mokradí mali výraznejšie brať do úvahy problémy súvisiace s vodnými cyklami.