EFFECT OF WINTER WATER STRESS ON THE BREEDING BIRD ASSEMBLAGE OF A REMNANT WETLAND IN CENTRAL ITALY

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RÉSUMÉ. — *Effet du stress hydrique hivernal sur la communauté d'oiseaux nicheurs d'une zone humide résiduelle en Italie centrale*.— Nous avons évalué les effets du stress hydrique hivernal sur les peuplements d'oiseaux nicheurs et deux communautés d'espèces (des roselières humides et des milieux ouverts) dans une zone humide résiduelle du centre de l'Italie. Les données ont été obtenues par cartographie durant une période de cinq ans (2001-2005) comprenant une année de stress hydrique (2002). Au niveau du peuplement, la richesse spécifique, l'indice de diversité et celui de l'équirépartition ainsi que la biomasse consommante ont affiché leurs plus faibles valeurs durant la saison de reproduction 2002 mais seul le dernier paramètre a montré des différences significatives avec l'année précédente (2001) et suivante (2003). Durant les périodes appariées 2001-2002 et 2002-2003, le renouvellement des espèces fut le plus grand et l'indice de similarité le plus petit. En ne considérant que la communauté des roselières humides, on a observé que la richesse spécifique a diminué en 2002 comparativement aux autres années ; les valeurs de l'indice de diversité et la biomasse consommante ont changé de manière significative entre cette année et à la fois la précédente (2001) et la suivante (2003) ; la densité écologique (*i.e.* la densité dans l'habitat convenable) de ces espèces fut significativement plus faible en 2002 qu'en 2001. La baisse significative de la biomasse consommante fut due à la disparition locale des espèces plus strictement liées aux habitats aquatiques et aux phragmitaies, avec une masse corporelle moyenne plus forte que celle des espèces des milieux ouverts. Aucun changement similaire ne fut observé chez les espèces des milieux ouverts. Les changements entre années furent plus dus au renouvellement des espèces qu'à celui de leurs abondances. Les conditions d'habitat des zones humides, *i.e.* liées au niveau d'eau, ont été cruciales pour la variation interannuelle de la richesse spécifique et de la densité des oiseaux nicheurs dans la zone d'étude.

SUMMARY. — We evaluated the effects of winter water stress on breeding bird communities and two assemblages of species (wet-reed species and open-habitat species) in a remnant coastal wetland of central Italy. Data were obtained by means of mapping method, on a five year-period (2001-2005), comprising a water stress year (2002). At community level, species richness, diversity index, evenness and consuming biomass showed the lowest values in the 2002 breeding season, but only the last parameter showed significant differences with the previous (2001) and subsequent (2003) years. In the paired years 2001-2002 and 2002-2003, species turnover was highest and percentage similarity index was lowest. Only considering the wet-reed assemblage, we observed that: species richness decreased in 2002 in comparison to other years; the values of diversity index and consuming biomass changed significantly between that year and both previous (2001) and subsequent year (2003); ecological density (i.e. density in the suitable habitat) of these species was significantly lower in 2002 year compared to 2001. The significant decrease of the consuming biomass was due to the local disappearance of the species more strictly linked to water habitats and to the *Phragmites* reed-beds, with a higher mean body mass as compared to open-habitat species. No similar changes were observed for open-habitat species. Changes between years were more due to species turnover rather than abundance turnover. Wetland habitat conditions, i.e. linked to water level, were crucial to year-to-year variation in breeding bird species richness and density in the study area.

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Remnant wetlands in fragmented landscapes suffer disturbances from the nearby anthropized environments, to the extent that processes inside these fragments may be under the complete control of the surrounding transformed landscape matrix (Tscharntke, 1992; Harris & Silva Lopez, 1992; Farina, 2001). One of the main disturbances is the water stress caused by the reduced flow of superficial running water and the pumping up of water into the surrounding areas (e.g. for irrigation). In similar conditions, rain may be the only water input for wetlands. Thus, scarce precipitations could be considered a stochastic factor that may cause marked effects on wetland-associated animal populations and communities in isolated wetlands (Saunders *et al.*, 1991; Báldi & Kisbenedeck, 1998; Graveland, 1998; Moskát & Báldi, 1999; Barbraud *et al.*, 2002; Krapu *et al.*, 2006).

In this study, we refer to the term 'water stress' such as the impact of an abrupt and not predictable event of seasonal drought in a network of channels going through a wetland study area. This event may occur in a different period (e.g., winter) and with a different intensity when compared to the natural hydrologic regime of a Mediterranean wetland. In this work we refer only to the hydrologic variables (i.e., a water level metric) of the water stress, not on chemical or physical ones (e.g., salinity, flood).

Water stress may represent a natural or an indirect anthropical disturbance for many bird species linked to wetland environments (Gilbert *et al.*, 2005; Krapu *et al.*, 2006). Water stress may negatively affect wetland bird species adapted to aquatic habitats (Dimalexis & Pyrovetsi, 1997; Arengo & Baldassarre, 1999; Bancroft *et al.*, 2002; Steen *et al.*, 2006), in particular the species that rely on these habitats for foraging and breeding (Bancroft *et al.*, 2002, Johnson *et al.*, 2007). A reduction in water volume and surface may correspond to a habitat loss for wetland obligate birds, inducing a population decline in many species, especially if area-sensitive (Dolman & Sutherland, 1995). Moreover a decrease of water level in wetlands could act as a driving force to increase other natural or indirectly human-induced disturbances (e.g. predation on waders: Rosa *et al.*, 2006; decrease of food availability in ducks: Nummy & Pöysä, 1995; change in fish species community structure and diversity and consequences on piscivorous birds: Summerfelt, 1971; change in arthropod availability for reed passerines: Poulin *et al.* 2002).

Effects of these disturbances could differ among species assemblages. The approach for assemblages has been widely used in the last three decades in management and conservation studies (Verner, 1984; Magurran, 2004; Lorenzetti & Battisti, 2006).

Despite some studies were undertaken with regard to the effects of water stress on single species (e.g. Cézilly *et al.*, 1995; Strong *et al.*, 1997; Báldi & Kisbenedeck, 1998; Arengo & Baldassarre, 1999; Gilbert *et al.*, 2005; Boertmann & Ricet, 2006; Krapu *et al.*, 2006; Paillison *et al.*, 2006), further investigations on the effects at assemblage level are requested, especially in the Mediterranean context. In particular, in Mediterranean areas, some studies at community level focused especially on the effect of habitat fragmentation and, secondarily, on the consequences of water stress (e.g. Celada & Bogliani, 1993; Paracuellos, 2006). Moreover, despite the usefulness of studying the disturbance regimes in a long term period, many studies focused their analysis only on short time (Hobbs & Huenneke, 1992).

In central Italy, winter 2001-2002 was characterized by scarce rainfall. This produced a marked water stress in a protected residual wetland of the Tyrrhenian coast, which led to a partial drying up during the 2002 breeding season (total in reed-bed covered area, partial in the channels used for fish farming). This phenomenon allowed the evaluation of the effects of an abrupt water level change on bird communities in a remnant wetland. Aim of the present study was to evaluate the effects of a winter water stress on breeding bird communities and two ecological (habitat related) assemblages of species in a remnant coastal wetland area, comparing data recorded on a five year-period (2001-2005), including a dry year (2002).

MATERIAL AND METHODS

STUDY AREA

The study area is included in 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 (Special Area of Conservation, according to the EC Directive on the Conservation of Wild Bird 79/409/EC), relict of a larger wetland drained and transformed by land reclamation in the last Century (Battisti, 2006; Battisti *et al.*, 2006).

At landscape scale, this area shows characteristics of a remnant fragment of wetland inside an agricultural and urbanized matrix. At local scale, it shows a seminatural heterogeneity with *Phragmites australis* reed-beds, channels used for fish farming (prevalently, three species of mullets, *Mugil cephalus*, *Liza saliens, Liza ramada*), flooded meadows with *Carex hirta, Juncus acutus* and Cyperaceae corresponding to *Juncetalia maritimi* habitat type according EC "Habitat" Directive 92/43/EC, dune and backdune areas. Hereafter, we refer to "open habitat" to comprise flooded meadows, edge areas, dunes and backdunes.

Climate is xeric-meso-Mediterranean (Tomaselli *et al.*, 1973; Blasi & Michetti, 2005). The water in the wetland area is mainly of meteoric and seastorm origin and flow from surrounding areas is scarce. Depth is variable in time, and no water is present from July to October (Battisti, 2006). Water stress is one of the main local direct threats known for Torre Flavia wetland (Battisti *et al*., 2008).

WATER LEVEL

Each year from 2002 to 2005, between 20.III and 20.VI, we measured the water level in the wetland channels with a metric pole (+/- 1 cm) once each ten days in a single sampling point (hydrometric station of Torre Flavia). These channels have been artificially built in the first half of XXth Century for fish farming and show vegetated banks and a regular depth. Water level measured in this point is representative of water level in the whole of the channel network (Battisti, 2006). During the breeding season 2001 water level data were not available.

SAMPLING TECHNIQUES

In five consecutive years (2001-2005), in an 11 ha area inside the "Torre Flavia" natural Monument (about 6 ha within the *Phragmites australis* reed-bed and about 5 ha within open habitats), bird communities were monitored by means of mapping census method (Bibby *et al.*, 2000). During each breeding seasons (March-July), a number of periodic visits were carried out with a comparable sampling effort (2001: 26 hours of sampling; 2002: 23; 2003: 26; 2004: 27; 2005: 24; differences among hours of sampling in five years are not significant: $\chi^2 = 0.434$, d.f. = 4; NS). In each visit, the observer collected data following a non linear transect (2,200 m-long) in early morning (07.00 -10.00h a.m.).

Contacts (i.e. records of each individual bird) were noted on a local map (scale 1: 2,000 from 1:10,000 Technical Regional Map; Regione Lazio, 1990). Species-specific maps were created and species-specific territories were obtained following the clustering procedure described in Bibby *et al.* (2000). One point was given to territories (i.e. clusters of individual species-specific contacts) completely inside the study area and 0.5 point to edge territories (i.e. clusters partially included in the 11 ha study area). We considered a "territory" as a range area inside which a species pair was considered to breed (i.e. one territory = one breeding pair; Bibby *et al.*, 2000).

Due to the limited vocalizations of *Tachybaptus ruficollis* (Pallas, 1764), *Anas platyrhynchos* Linnaeus, 1758, *Gallinula chloropus* (Linnaeus, 1758), and *Fulica atra* Linnaeus, 1758, an estimated value of the density of such species was drawn from the counting of the observed individuals. Species that utilized the study area only for foraging or roosting, but not for breeding, e.g. *Hirundo rustica* Linnaeus, 1758*, Pica pica* (Linnaeus, 1758), *Corvus corone cornix* Linnaeus, 1758*, Sturnus vulgaris* Linnaeus, 1758, *Passer italiae* (Vieillot, 1817), were not considered in this study.

As surveys were carried out in the morning time, species with crepuscular or nocturnal activity such as Strigiformes were not considered. Also individuals flying very high (i.e. higher than 25 m), and species with home ranges larger than the study area (e.g. gulls and raptors), were not considered.

DATA ANALYSIS

We analysed data at community and assemblage level. We refer to the term "community" to indicate a set of species that co-occur at a given time, spatial scale or area, (i.e. breeding bird species in our wetland study area) and to the term "assemblage" to indicate a set of interacting species that share resources and/or are linked to the same habitat type for breeding (Verner, 1984; Magurran, 2004). We selected two assemblages comprising:

i) species mainly found in the *Phragmites australis* reed-beds (hereafter: wet-reed species - Ph);

ii) species found in the open habitats (see above; hereafter: open-habitat species - Oh; Tab. II).

In each year, the following parameters were calculated:

– species richness, as the number of species occurring in the study area for the overall community (S_{Tot}) and for each assemblages (S_{Ph}: wet-reed species richness and S_{Oh}: open-habitat species richness);

– breeding pair density (D), expressed as number of territories (i.e. breeding pairs)/10 ha and calculated for each species and all species (D_{Tot});

– relative frequency for each species (fi) as the ratio: specific density / D_{Tot}; species with fi > 0.05 were considered dominant species (Turček, 1956; Wiens, 1989);

– ecological density (ED) referred to species density in the most suitable habitat, expressed as number of breeding pairs per10 ha of suitable habitat, for each assemblages (ED_{Ph}: wet-reed species and ED_{Oh}: open-habitat species); in patchy habitat types such as wetlands this measure is more appropriate to assess the effective density of a strictly-habitat related species within their habitat (Wiens, 1989);

– Shannon diversity index (H; Shannon & Weaver, 1963 as $H = -\Sigma$ fi ln fi), at community and assemblage level;

– evenness index ($J = H/H_{max}$; Lloyd & Ghelardi, 1964; where $H_{max} = \ln S$; Pielou, 1966);

– consuming biomass (Cb; in g/10 ha; calculated as: $Cb = Scb^{0.7}$ (Salt, 1957), where Scb, or standing crop biomass, is the total body mass of all censused individuals, in g/10 ha). We used consuming biomass more than standing crop biomass, because the former explained better the specific variations of metabolic rhythm mainly related to individual size. This value is directly proportional to energy removed by individuals from environment (Salt, 1957).

To calculate the biomass values, mean body mass values for *Tachybaptus ruficollis, Anas platyrhynchos, Gallinula chloropus, Fulica atra, Charadrius dubius* Scopoli, 1786, and *Galerida cristata* (Linnaeus, 1758) were obtained from Cramp and Simmons (1977, 1980, 1983); Cramp (1988); mean body mass of *Ixobrychus minutus* (Linnaeus, 1766), *Motacilla alba* Linnaeus, 1758, *Serinus serinus* (Linnaeus, 1766), *Carduelis carduelis* (Linnaeus, 1758), and *Miliaria calandra* (Linnaeus, 1758) were obtained from 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 were obtained by the data archives of the local ringing station (Sorace *et al.*, 2006).

Turnover of species between couple of years was calculated as:

$$t = b + c / S_1 + S_2$$

where *b* is the number of species present only in the first year; *c* is the number of species present only in the second year; S_1 and S_2 are the total number of species recorded in the first and second year, respectively (Brown & Kodric-Brown, 1977; Magurran, 2004). This index does take into account the relative frequency of individuals of each species; therefore, to assess differences among years also on this basis, we used the percentage similarity index between years (Southwood & Henderson 2000) as:

$$PS = 100 - 0.5 \sum | P_{ai} - P_{bi}|$$

where P_{ai} and P_{bi} are the percentage densities of species *i* in yearly samples *a* and *b*, respectively. The index varies from 0 (in case of complete dissimilarity) to 100 (in case of complete similarity).

Data of species richness and evenness index, at community and assemblage level, were plotted in a Cartesian space. The diagram obtained makes spatially explicit the differences in structure of communities and assemblages (Ukmar *et al.*, 2007).

Mean values of water level in the study area were compared with non parametric Mann-Whitney U test between breeding seasons and Kruskal-Wallis test among all years.

Species richness between paired years was tested using χ^2 test (1 degree of freedom; Yates'correction).

We performed the non parametric Kolmogorov-Smirnov test to compare the Shannon diversity indexes between communities and assemblages. Total and ecological densities and consuming biomass were compared between paired years using Wilcoxon signed ranks tests (single species as statistical unit). Significance levels were set at P < 0.05 and P < 0.01. We used statistical package SPSS 13.0 for Windows.

RESULTS

WATER LEVEL

Differences in mean water level among years were significant (2002-2005: H = 12.282; 3 d.f., P = 0.008; Kruskal-Wallis test). In pairwise comparisons, only differences between 2002 and 2003 were significant (Mann Whitney U test; Tab. I).

TABLE I

Mean values (± SD) of water level in Torre Flavia wetland (central Italy)

2002	2003	2004	2005
56.15 (± 9.56)	89.20 (± 21.44)	93.90 (± 36.01)	100.30 (± 24.64)
	U = 14.5*	U = 38	U = 49.5

The differences between values has been tested with Mann-Whitney U test. * P < 0.05.

COMMUNITY LEVEL

The values of species richness, diversity, evenness and consuming biomass were the lowest in the 2002, but only consuming biomass showed significant differences with previous (2001) and subsequent (2003) years (Tables II-V).

TABLE II

Composition of bird communities and assemblages in five breeding season (2001-2005) in Torre Flavia wetland (central Italy)

ht	Species	2001				2002				2003				2004				2005			
		D	fi	ED	Cb	D	fi	ED	Cb	D	fi	ED	Cb	D	fi	ED	Cb	D	fi	ED	Cb
Ph	*Tachybaptus ruficollis*	3.64	**0.100**	6.67	172.83					3.64	**0.105**	6.67	172.71	1.82	0.048	3.33	106.31	0.91	0.024	1.67	65.44
Ph	*Ixobrychus minutus*	0.91	0.025	1.67	34.34					0.91	0.026	1.67	34.32	0.91	0.024	1.67	34.32	0.91	0.024	1.67	34.32
Ph	*Anas platyrhynchos*	2.73	**0.075**	5.00	455.12	1.82	**0.076**	3.33	342.66	2.27	**0.066**	4.17	400.31	2.27	**0.060**	4.17	400.31	1.82	0.048	3.33	342.42
Ph	*Rallus aquaticus*									1.82	**0.053**	3.33	68.38	0.91	0.024	1.67	42.10	0.91	0.024	1.67	42.10
Ph	*Gallinula chloropus*	3.64	**0.100**	6.67	227.31					3.18	**0.092**	5.83	206.88	3.64	**0.095**	6.67	227.15	3.64	**0.095**	6.67	227.15
Ph	*Fulica atra*	1.82	**0.050**	3.33	274.82					3.18	**0.092**	5.83	406.32	4.55	**0.119**	8.33	521.55	5.00	**0.131**	9.17	557.53
Oh	*Charadrius dubius*	0.91	0.025	2.00	20.11	0.45	0.019	1.00	12.29	0.45	0.013	1.00	12.37	0.45	0.012	1.00	12.37	0.45	0.012	1.00	12.37
Oh	*Galerida cristata*	0.91	0.025	2.00	21.67	1.36	**0.057**	3.00	28.71	0.45	0.013	1.00	13.33	0.45	0.012	1.00	13.33	0.45	0.012	1.00	13.33
Oh	*Motacilla alba*	0.45	0.012	1.00	7.40	0.91	0.038	2.00	12.12	0.45	0.013	1.00	7.46					0.91	0.024	2.00	12.11
Oh	*Saxicola torquata*	0.91	0.025	2.00	9.79	0.45	0.019	1.00	5.98	0.45	0.013	1.00	6.02	0.45	0.012	1.00	6.02	0.45	0.012	1.00	6.02
Oh	*Cettia cetti*	1.36	0.037	2.50	11.47	0.91	0.038	1.67	8.66	1.82	**0.053**	3.33	14.06	4.09	**0.107**	7.50	24.80	5.91	**0.155**	10.83	32.08
Oh	*Cisticola juncidis*	6.36	**0.175**	14.00	28.89	5.91	**0.246**	13.00	27.44	6.36	**0.184**	14.00	28.90	6.36	**0.167**	14.00	28.90	6.36	**0.167**	14.00	28.90
Ph	*Acrocephalus scirpaceus*	9.55	**0.263**	17.50	41.97	9.09	**0.378**	16.67	40.54	6.36	**0.184**	11.67	31.59	10.00	**0.262**	18.33	43.34	7.73	**0.202**	14.17	36.19
Ph	*Acrocephalus arundinaceus*	0.91	0.025	1.67	16.56									0.91	0.024	1.67	16.54				
Oh	*Serinus serinus*	0.45	0.012	1.00	5.01					0.45	0.013	1.00	5.04								
Oh	*Carduelis chloris*	0.45	0.012	1.00	8.79	0.45	0.019	1.00	8.79	0.45	0.013	1.00	8.85	0.45	0.012	1.00	8.85	1.82	0.048	4.00	23.37
Oh	*Carduelis carduelis*	0.45	0.012	1.00	6.47	0.45	0.019	1.00	6.47	0.45	0.013	1.00	6.51								
Oh	*Miliaria calandra*	0.91	0.025	1.00	21.05	2.27	**0.094**	5.00	39.92	1.82	**0.053**	4.00	34.18	0.91	0.024	2.00	21.04	0.91	0.024	2.00	21.04
	Total	36.36	1		1,363.61	24.07	1		533.59	34.55	1		1,457.23	38.17	1		1,506.93	38.18	1		1,454.37
	Ph			45.01	1,234.42			21.67	391.86			42.50	1,334.57			53.34	1,416.42			49.17	1,337.23
	Oh			26.00	129.19			27.00	141.73			25.00	122.66			20.00	90.52			25.00	117.14

ht: habitat type; Ph: wet-reed species; Oh: open-habitat species; D = density; fi = relative frequency; ED = ecological density referred to species density in the most used habitat types; Cb = consuming biomass (in g/10 ha). In bold: dominant species (fi > 0.05; Turček, 1956).

TABLE III

Values of species richness (S_{Tot}: total species; S_{Ph}: wet-reed species; S_{Oh}: open habitat species); Shannon diversity index (H), evenness (J) and consuming biomass (Cb) in Torre Flavia wetland (central Italy)

		2001	2002	2003	2004	2005
Total	S_{Tot}	17	11	17	15	15
	H	2.36	1.84	2.44	2.25	2.29
	J	0.83	0.77	0.86	0.83	0.85
	Cb	1,363.61	533.59	1,457.24	1,506.94	1,454.37
Ph	S_{Ph}	8	3	8	9	8
	H	1.77	0.69	1.57	1.65	1.80
	J	0.85	0.63	0.76	0.75	0.86
	Cb	1,234.42	391.86	513.66	1,416.42	1,337.23
Oh	S_{Oh}	9	8	9	6	7
	H	1.62	1.59	0.87	0.60	1.41
	J	0.74	0.76	0.40	0.37	0.72
	Cb	129.19	141.73	122.67	90.52	117.14

TABLE IV

Pairwise comparisons between consecutive years for the parameters used to describe the Torre Flavia wetland communities and the two study assemblages

		2001-2002	2002-2003	2003-2004	2004-2005
Total	S_{Tot}^1	0.89	0.89	0.03	0.03
	H^2	0.19	0.26	0.09	0.6
	D^3	2.226	1.474	0.536	0.070
	Cb^3	2.158*	1.917*	0.178	0.420
Ph	$S_{Ph}1$	1.45	0.00	0.00	0.00
	H^2	0.39 *	0.49 **	0.07	0.06
	ED_{Ph}^3	2.539*	1.823	1.183	0.841
	Cb^3	2.521*	2.240*	0.507	0.943
Oh	S_{Oh}^1	0.00	0.00	0.27	0.00
	H^2	0.09	0.08	0.14	0.14
	ED_{Oh}^3	0.000	0.707	1.890	0.180
	Cb^3	0.169	0.059	1.826	1.342

(Ph: wet-reed species; Oh: open habitat species). Species richness (S_{Tot}: total species; S_{Ph}: wet-reed species; S_{Oh}: open habitat species); H: Shannon diversity index; density (D); ecological density (ED_{Ph}: wet-reed species and ED_{Oh}: open habitat-species); Cb: consuming biomass. [1]: χ^2 test (Yates correction); [2]: Kolmogorov-Smirnov non parametric test (D values); [3]: Wilcoxon paired test (Z values) obtained using single species as statistical unit; * P < 0.05; ** P < 0.01.

In the paired years 2001-2002 and 2002-2003 species turnover was higher and percentage similarity index was slightly lower than in other pairwise comparisons (Tab. V).

TABLE V

Species turnover (T) and percentage similarity index (PS) between consecutive years at community and assemblage level

		2001-2002	2002-2003	2003-2004	2004-2005
T	Total	0.21	0.21	0.13	0.07
	Ph	0.46	0.46	0.06	0.06
	Oh	0.06	0.06	0.20	0.08
PS	Total	83.33	81.59	87.08	91.25
	Ph	88.33	84.59	89.58	93.75
	Oh	95.00	97.00	97.50	97.50

ASSEMBLAGE LEVEL

Wet-reed species richness, decreased in 2002 compared to other years (Tab. III). The values of Shannon diversity index and consuming biomass were significantly lower in this year than in previous (2001) or subsequent years (2003; Tab. IV). Wet-reed ecological density was significantly different between 2001 and 2002 (Tab. IV).

Water stress induced in 2002 a local temporary lack of sampling of some species (e.g. *Tachybaptus ruficollis*, *Ixobrhychus minutus, Gallinula chloropus, Fulica atra*) in the wet fragment studied (Tab. II) that were sampled in years with ordinary water level (> 80 cm in average; Tab. I).

In the paired years 2001-2002 and 2002-2003, wet-reed species turnover showed the highest values (> 0.20) whereas the percentage similarity index was slightly lower than in other pairwise comparisons (Tab. V). In open-habitat species, no significant differences in the values of parameters (species richness, diversity, consuming biomass and ecological density) were observed in paired years (Tab. IV). The percentage similarity index did not show clear differences among years (Tab. V).
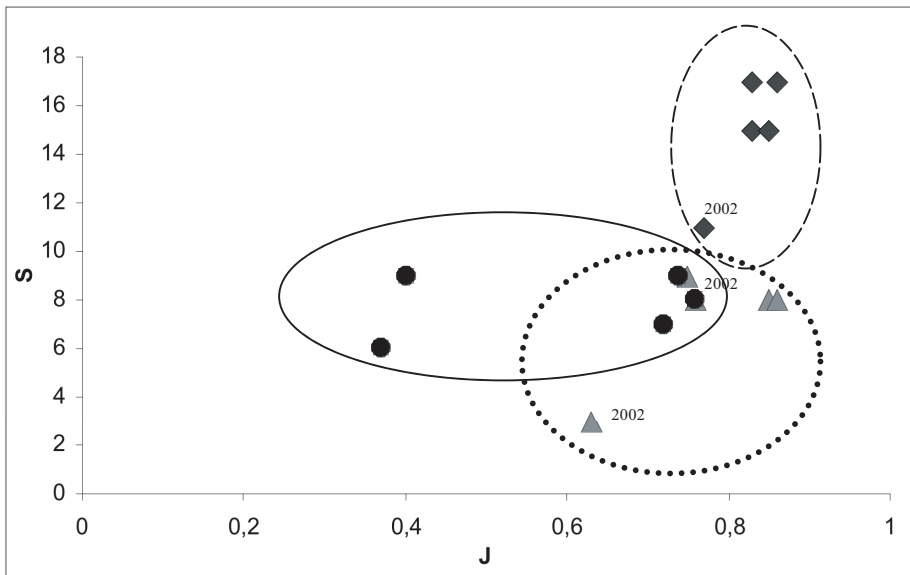

Figure 1. — Relationship between richness (S) and evenness (J) during five breeding seasons (2001-2005). Diamonds: total community (dashed line); triangles: wet-reed species (dotted line); circles: open habitat species (continuous line).

Species richness/evenness diagram showed a wider range in evenness of open-habitat species as compared to wet-reed species. Range in species richness was wider in the wet-reed species (Fig. 1).

DISCUSSION

The scarce rains in 2001-2002 winter and consequent reduction of water level disrupted the 2002 breeding bird community and habitat related assemblages in the study area.

At community level, water stress induced a reduction of total species richness, diversity index and consuming biomass in the 2002 breeding season, but the differences were significant only for the consuming biomass.

At wet-reed assemblage level, water stress induced a disruption of some community parameters: e.g. a strong reduction of species richness, and a significant reduction of the diversity index and consuming biomass in the 2002 breeding period.

The significant decrease of the consuming biomass in the breeding bird community and in wet-reed species was due to the local disappearing of the species more strictly linked to water habitats and to the *Phragmites* reed-beds (e.g. Anatidae, Rallidae and other species of the wet-reed assemblage). These species have a higher mean body mass compared to open-habitat species (cf. Cramp & Simmons, 1977, 1980, 1983; Cramp, 1988), so their local disappearance induced strong changes in total biomass.

No significant reduction in species number, diversity index and consuming biomass was observed for open-habitat species. In heterogeneous open habitat surrounding reed-beds (*Juncetalia maritimi* flooded meadows, crop-lands), some open-habitat related species (i.e. non water associated species) were always present, e.g. *Cisticola juncidis* (Refinesque, 1810), *Carduelis chloris* (Linnaeus, 1758), *Miliaria calandra.* These species prefer edge and/or xeric habitat (cf. Cramp, 1988) and could perceive a higher suitability when the areas surrounding this remnant wetland tend to dry out.

Changes between years were due more to species turnover than to individual abundance turnover. Species turnover was high particularly in paired years 2001-2002 and 2002-2003. In 2002 many species were not sampled, influencing the species turnover in total community and in wet-reed assemblage. Nevertheless, the absence of wet-reed species in 2002 could be either a true absence (local extinction or emigration) or a false absence due to a variation of detection probability of individuals. In this sense, species that "disappeared" from wetland may have partly retreated to within-reed bed, and therefore became temporarily not detectable and show a false absence (see Boulinier *et al.*, 1998).

Percentage similarity of communities or assemblages was always high between years (> 81 %). This was mainly due to the constant density of the two most abundant species, *Acrocephalus scirpaceus* (Hermann, 1804) (a wet-reed species) and *Cisticola juncidis* (an open-habitat species) that did not show significant changes among years (Tab. II).

The species richness/evenness diagram support the considerations on the different consequences of water stress on the two selected assemblages. Water level decrease in 2002 acted reducing the wet-reed species richness and evenness. The low abundance of open-habitat species induced high oscillation in evenness among years (high range in evenness values) that are not related to water stress.

Previous studies documented relationships between bird richness or abundance and water levels within wetland basins, in breeding and wintering periods (e.g. Cowardin *et al.*, 1998; Austin, 1992; Gilbert *et al.*, 2005; Krapu *et al.*, 2006), but these studies focused mainly on ducks and other waterfowl. Few data are available for other water-associated birds (e.g. Passeriformes), for the whole community of breeding birds and for specific ecological assemblages.

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 other factors (competition with generalist species, anthropical disturbances). This may be particularly true for many

Mediterranean wet fragments where, due to the excessive water catching and recent climatic changes, the hydrologic balance is source of concern (Blondel & Aronson, 1999).

Negative effects in fluctuations of water levels on some sensitive bird species living in such areas were widely reported. For example, water level oscillations reduced the wetland habitat available for wet-reed species (e.g. *Tachybaptus ruficollis, Anas platyrhynchos, Fulica atra,* area-sensitive species; Celada & Bogliani, 1993; McCollin, 1993; Báldi & Kisbenedek, 1998) and could promote the access to the reed-beds for the terrestrial predators, increasing the impact on breeding bird reproductive success (Catchpole, 1974; Thomas *et al.*, 1999). Moreover, ducks and other water-obligated birds may interpret shallow water depth, drought and exposed mud flats in breeding periods as evidence of poor or declining habitat suitability (*sensu* Morrison *et al.*, 1992) and move elsewhere to breed (Austin, 1992).

Despite the sensitivity to the edge and area effect for *Acrocephalus* species (Opdam *et al.*, 1994; Báldi & Kisbenedeck,1999; Moskát & Báldi 1999), in this study the densities of *Acrocephalus scirpaceus* did not seem to be clearly affected by the reduced suitability (e.g. water level oscillations) and, consequently, by reduced habitat size area (see also Catchpole, 1973, 1974).

Effects of water level oscillation may depend on the spatial scale. As highlighted in reviews about landscape fragmentation (Andrén, 1994; Fahrig, 1997, 2003), wetland quality (i.e. suitable water level for sensitive species and assemblages) is likely the main predictor of bird richness and abundance at local scale, whereas at landscape scale, wetland density, wetland size class distribution, total water availability and matrix features may operate. In addition, other factors here not considered (e.g. non water-related food availability, change in vegetation cover, year-to-year stochasticity in resource availability or climate) can affect bird occurrence, density and richness at local scale (i.e. at single wetland level; Austin, 2002). Therefore, additional work is needed to quantify how water stress induces changes in bird community structure at different levels (e.g. if for a seasonal gradient or for abrupt thresholds, if widely diffused or limited) and at multiple scale.

REFERENCES

ANDRÉN, H. (1994). — Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos*, 71: 355-366.

ARENGO, F. & BALDASSARRE, G.A. (1999). — Resource variability and conservation of American Flamingos in coastal wetlands of Yucatan, Mexico. *J. Wildl. Manag.*, 63: 1201-1212.

AUSTIN, J.E. (2002). — Responses of dubbling ducks to wetland conditions in the Prairie Pothole region. *Waterbirds*, 25: 465-473.

BÁLDI, A. (1999). — Microclimate and vegetation edge effects in a reedbed in Hungary. *Biodiv. Conserv.*, 8: 169-1706.

BÁLDI, A. & KISBENEDEK, T. (1998). — Factors influencing the occurrence of Great White Egret (*Egretta alba*), Mallard (*Anas plathyrhynchos*), Marsh Harrier (*Circus aeruginosus*), and Coot (*Fulica atra*) in the reed archipelago of Lake Velence, Hungary. *Ekològia (Bratislava)*, 17: 384-390.

BÁLDI, A. & KISBENEDEK, T. (1999). — Species-specific distribution of reed-nesting passerine birds across reed-bed edges: effects of spatial scale and edge type. *Acta Zool. Hung.*, 45: 97-114.

BANCROFT, G.T., GAWLIK, D.E. & RUTCHEY, K. (2002). — Distribution of wading bird relative to vegetation and water depths in the Northern Everglades of Florida, USA. *Waterbirds*, 25: 265-277.

BARBRAUD, C., LEPLEY, M., MATHEVET, R. & MAUCHAMP, A. (2002). — Reedbed selection and colony size of breeding Purple Herons *Ardea purpurea* in southern France. *Ibis*, 144: 227-235.

BATTISTI, C. (ed.) (2006). — *Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico: la Palude di Torre Flavia*. Provincia di Roma, Gangemi editore, Roma.

BATTISTI, C., LUISELLI, L., PANTANO, D. & TEOFILI, C. (2008). — On threats analysis approach applied to a Mediterranean remnant wetland: Is the assessment of human-induced threats related to different level of expertise of respondents? *Biodiv. Cons.,* 17: 1529-1542.

BATTISTI, C., SORACE, A., DE ANGELIS, E., GALIMBERTI, C. & TRUCCHIA, N. (2004). — Waterbird abundance in a residual wetland of central Italy during two years of contrasting water level. *Avocetta*, 28: 86-90.

BATTISTI, C., SORACE, A., DE ANGELIS, E., GALIMBERTI, C. & TRUCCHIA, N. (2005). — Ciclo biennale di Ardeidi, Anatidi, Rallidi nella palude di Torre Flavia (Roma, Italia centrale). *Riv. ital. Orn.*, 75: 3-16.

BATTISTI, C., AGLITTI, C., SORACE, A. & TROTTA, M. (2006). — Water level and its effect on the breeding bird community in a remnant wetland in Central Italy. *Ekològia (Bratislava)*, 25: 252-263.

BEGON, M., HARPER, J.L. & TOWNSEND, C.R. (1986). — *Ecology. Individuals, populations and communities*. Blackwell Scientific Publication, London.

BERNONI, M. (1984). — Il metodo del mappaggio in una zona umida del Lazio: le Vasche di Maccarese. *Riv. ital. Orn.*, 54: 235-243.

BIBBY, C.J., BURGESS, N.D., HILL, D.A. & MUSTOE, S. (2000). — *Bird Census Techniques*. 2nd edition. Academic Press, London.

BLASI, C. & MICHETTI, L. (2005). — Biodiversità e Clima. *In*: C. Blasi, L. Boitani, S. La Posta, F. Manes & M. Marchetti (eds.). *Stato della biodiversità in Italia. Contributo alla strategia nazionale per al biodiversità*. Ministero dell'Ambiente e della Tutela del territorio. F.lli Palombi editori, Roma.

BLONDEL, J. & ARONSON, J. (1999). — *Biology and wildlife of Mediterranean Region*. Oxford University Press, Oxford.

BOERTMANN, D. & RICET, F. (2006). — Effects of changing water levels on numbers of staging dabbling ducks in a Danish wetland. *Waterbirds*, 29: 1-8.

BOULINIER, T., NICHOLS, J.D., SAUER, J.R., HINES, J.E. & POLLOCK, K.H. (1998). — Estimating species richness: the importance of heterogeneity in species detectability. *Ecology*, 79: 1018-1028.

BROWN, J.H. & KODRIC-BROWN, A. (1977). — Turnover rates in insular biogeography: effect of immigration on extinction. *Ecology*, 58: 445-449.

CATCHPOLE, C.K. (1973). — Conditions of co-existence in sympatric breeding populations of *Acrocephalus* warblers. *J. Anim. Ecol.*, 42: 623-635.

CATCHPOLE, C.K. (1974). — Habitat selection and breeding success in the reed warbler (*Acrocephalus scirpaceus*). *J. Anim. Ecol.*, 43: 363-380.

CELADA, C. & BOGLIANI, G. (1993). — Breeding bird communities in fragmented wetlands. *Boll. Zool.*, 60: 73-80.

CÉZILLY, F., BOY, V., GREEN, R.E., HIRONS, G.J.M. & JOHNSON, A.R. (1995). — Interannual variation in Greater Flamingo breeding success in relation to waterlevels. *Ecology*, 76: 20-26.

CONNOR, K.J. & GABOR, S. (2006). — Breeding waterbird wetland habitat availability and response to water-level management in Saint John River foodplain wetlands, New Brunswick. *Hydrobiologia*, 567: 169-181.

COWARDIN, L.M., PIETZ, P.J., LOKEMOEN, J.T., SKLEBAR, H.T. & SARGEANT, G.A. (1998). — Response of nesting ducks to predator enclosures and water conditions during drought. *J. Wildl. Manag.*, 62: 152-163.

CRAMP, S. (ed.) (1988). — *The Birds of the Western Paleartic*. Vol. V. Oxford University Press, Oxford.

CRAMP, S. & SIMMONS, K.E.L. (eds) (1977). — *The Birds of the Western Palearctic*. Vol. I. Oxford University Press, Oxford.

CRAMP, S. & SIMMONS, K.E.L. (eds) (1980). — *The Birds of the Western Palearctic*. Vol. II. Oxford University Press, Oxford.

CRAMP, S. & SIMMONS, K.E.L. (eds) (1983). — *The Birds of the Western Palearctic*. Vol. III. Oxford University Press, Oxford.

DIMALEXIS, A. & PYROVETSI, M. (1997). — Effect of water level fluctuations on wading bird foraging habitat use at an irrigation reservoir, Lake Kerkini, Greece. *Colonial Waterbirds*, 20: 244-252.

DOLMAN, P.M. & SUTHERLAND, W.J. (1995). — The response of bird populations to habitat loss. *Ibis*, 137: S38-S46.

FAHRIG, L. (1997). — Relative effects of habitat loss and fragmentation on population extinction. *J. Wildl. Manag.*, 61: 603-610.

FAHRIG, L. (2003). — Effects of habitat fragmentation on biodiversity. *Ann. Rev. Ecol. Syst.*, 34: 487-515.

FARINA, A. (2001). — *Ecologia del Paesaggio*. UTET Libreria, Torino.

FOWLER, J. & COHEN, L. (1992). — *Statistics for Ornithologists*. British Trust for Ornithology, London.

GILBERT, G., TYLER, G.A., DUNN, C.J. & SMITH, K.W. (2005). — Nesting habitat selection by Bitterns in Britain and the implications for wetland management. *Biol. Cons.*, 124: 547-553.

GRAVELAND, J. (1998). — Reed dye-back, water level management and the decline of the Great Reed Warbler *Acrocephalus arundinaceus* in the Netherlands. *Ardea*, 86: 187-201.

GUSTIN, M. & SORACE, A. (1999). — Considerazioni generali sull'attività di inanellamento in località Sentina, Porto d'Ascoli (Ascoli Piceno), durante il 1998. *Avocetta*, 23: 38.

GUSTIN, M. & SORACE, A. (2001). — Attività di inanellamento nella palude di Montepulciano (SI). *Avocetta*, 25: 214.

HAGEMEIJER, E.J.M. & BLAIR, M.J. (eds.). (1997). — *The EBCC atlas of European breeding birds: their distribution and abundance*. T and AY Poyser, London.

HAILA, Y. (1985). — Birds as a tool in reserve planning. *Ornis Fennica*, 62: 96-100.

HARRIS, L.D. & SILVA-LOPEZ, G. (1992). — Forest fragmentation and the conservation of biological diversity. Pp 197-237 *In*: P.L. Fiedler & S.K. Jain, (eds.). *Conservation Biology*. Chapman and Hall, New York, London..

HOBBS, R.J. & HUENNEKE, L.F. (1992). — Disturbance, diversity and invasions: implications for conservations. *Conserv. Biol.*, 6: 324-337.

KRAPU, G.L., PIETZ, P.J., BRANDT, D.A. & COX, R.R. JR. (2006). — Mallard brood movements, wetland use, and duckling survival during and following a prairie drought. *J. Wild. Manag.*, 70: 1436-1444.

JOHNSON, K.G., ALLEN, M.S. & HAVENS, K.E. (2007). —A review of littoral vegetation, fisheries, and wildlife responses to hydrologic variation at lake Okeechobee. *Wetlands*, 27: 110-126.

LEISLER, B. (1981). — Die oekologische Einnischung der mitteleuropäischen Rohrsänger (*Acrocephalus,* Sylviinae). I. Habitattrennung. *Vogelwarte*, 31: 45-74.

LLOYD, M. & GHELARDI, R.J. (1964). — A table for calculating the "Equitability" component of species diversity. *J. Anim. Ecol.*, 33: 217-225.

LORENZETTI, E. & BATTISTI, C. (2006). — Area as component of habitat fragmentation: corroborating its role in breeding bird communities and guilds of oak wood fragments in Central Italy. *Rev. Ecol. (Terre Vie)*, 61: 53-68.

MAGURRAN, A. (2004). — *Measuring biological diversity*. Blackwell Publishing, Malden, MA.

MCCOLLIN, D. (1993). — Avian distribution patterns in a fragmented wooded landscape (North Humberside, U.K.): the role of between-patch and within-patch structure. *Global Ecol. Biogeogr. Lett.*, 3: 48-62.

MESCHINI, E. & FRUGIS, S. (eds). (1993). — Atlante degli uccelli nidificanti in Italia. *Suppl. Ric. Biol. Selvaggina*, 20: 1-344.

MØLLER, A.P. (1987). — Breeding birds in habitat patches: random distribution of species and individuals? *J. Biogeogr.*, 14: 225-236.

MORRISON, M.L., MARCOT, B.G. & MANNAN, R.W. (1992). — *Wildlife-habitat relationships*. University of Wisconsin Press, Madison, USA.

MOSKÁT, C. & BÁLDI, A. (1999). — The importance of edge effect in line transect censuses applied in marshland habitats. *Ornis Fennica*, 76: 33-40.

NUMMY, P. & PÖYSÄ, H. (1995). — Breeding success of ducks in relation to different habitat factors. *Ibis*, 137: 145-150.

OPDAM, P., FOPPEN, R., REIJEN, R. & SCHOTMAN, A. (1994). —The landscape ecological approach in bird conservation: integrating the metapopulation concept into spatial planning. *Ibis*, 137: S139-S146.

PAILLISSON, J.-M., REEBER, S., CARPENTIER, A. & MARION, L. (2006). — Plant-water regime management in a wetland: consequences for a floating vegetation-nesting bird, whiskered tern *Chlidonias hybridus*. *Biodiv. Cons.*, 15: 3469-3480.

PARACUELLOS, M. (2006). — Relationship of songbird occupation with habitat configuration and bird abundance in patchy reed beds. *Ardea*, 94: 87-98.

PIELOU, E.C. (1966). — The measurement of diversity in different types of biological collections. *J. Theor. Biol.*, 13: 131-144.

POULIN, B., LEFEBVRE, G., MAUCHAMP, A. (2002). — Habitat requirements of passerines and reedbed management in southern France. *Biol. Cons.*, 107: 315-325.

REGIONE LAZIO (1990). — *Technical Regional Map*, scale 1: 10,000. Foglio 373660 "Ladispoli". Regione Lazio, Roma.

ROSA, S., ENCARNAÇAO, A.L., GRANADEIRO, J.P. & PALMEIRIM, J.M. (2006). — High water roost selection by waders: maximizing feeding opportunities or avoiding predation? *Ibis*, 148: 88-97.

SALT, G.W. (1957). — An analysis of avifaunas in the Teton Mountains and Jackson Hole. *Condor*, 59: 373-393.

SAUNDERS, D.A., HOBBS, R.J. & MARGULES, C.R. (1991). — Biological consequences of ecosystem fragmentation: a review. *Conserv. Biol.*, 5: 18-32.

SOUTHWOOD, T.R.E. & HENDERSON, P.A. (2000). — *Ecological methods*. Oxford, Blackwell Science, London.

SHANNON, C.E. & WEAVER, W. (1963). — *Mathematical Theory of Communication*. University of Illinois Press, Urbana, Illinois.

SORACE, A., BATTISTI, C., CECERE, J.C., DUIZ, A., GUSTIN, M. & SAVO, E. (2006). — Monitoraggio della migrazione ornitica mediante le attività di cattura e inanellamento. Pp 292-305 *In:* C. Battisti, (ed.). *Biodiversità, gestione, conservazione di un'area umida del litorale tirrenico: la Palude di Torre Flavia*. Provincia di Roma, Gangemi editore, Roma.

STEEN, D.A., GIBBS, J.P. & TIMMERMANS, S.T.A. (2006). — Assessing the sensitivity of wetland bird communities to hydrologic change in the Eastern Great Lakes Region. *Wetlands*, 26: 605-611.

STRONG, A.M., BANCROFT, G.T. & JEWELL, S.D. (1997). — Hydrological constraints on Tricolored Heron and Snowy Egret resource use. *Condor*, 99: 894-905.

SUMMERFELT, R.C. (1971). — Factors influencing the horizontal distribution of several fish in an Oklahoma reservoir. *American Fisheries Society Special Publication*, 8: 425-439.

THOMAS, F., DEERENBERG, C. & HAFNER, H. (1999). — Do breeding site characteristics influence breeding performance of the Puple Herons *Ardea purpurea* in the Camargue? *Rev. Ecol. (Terre Vie)*, 54: 269-281.

Tomaselli, R., Balduzzi, A. & Filippello, S. (1973). — *Carta Bioclimatica d'Italia.* Collana verde, 33. Ministero Agricoltura e Foreste, Roma.

Tscharntke, T. (1992). — Fragmentation of *Phragmites* habitats, minimum viable populations size, habitat suitability, and local extinction of moths, midges, flies, aphids, and birds. *Cons. Biol.*, 6: 530-536.

Turček, F.J. (1956). — Zur Frage der Dominanze in Vogelpopulationen. *Waldhygiene*, 8: 249-257.

Tyler, G.A., Smith, K.V. & Burges, D.J. (1998).— Reedbed management and breeding bitterns *Botaurus stellaris* in the UK. *Biol. Cons.*, 86: 257-266.

Ukmar, E., Battisti, C., Luiselli, L. & Bologna, M.A. (2007). — The effects of fires on communities, guilds and species of breeding birds in burnt and control pinewoods in central Italy. *Biodiv. Cons.*, 16: 3287-3300.

Verner, J. (1984). — The guild concept applied to management of bird populations. *Envir. Manage.*, 8: 1-14.

Whittaker, R.H. (1965). — Dominance and diversity in land plant communities. *Science*, 147: 250-260.

Wiens, J.A. (1989). — *The ecology of bird communities. Vol. 2. Processes and variations*. Cambridge studies in ecology, Cambridge University Press, Cambridge, UK.

Williams, M. (ed.) (1991). — *Wetlands: a threatened landscape.* Blackwell Publishers, Oxford.