Journal of Mediterranean Ecology **vol. 10, 2009: 13-18**

Applying Abundance/Biomass comparisons in breeding bird assemblages of a set of remnant wetlands in Central Italy

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Keywords: Abundance, biomass, ABC curves, birds assemblages, wetland fragments

Abstract

In this study we used a set of data related to a network of 16 wetland fragments in Central Italy (Litorale romano, Rome) with the aim to study the level of stress experimented by a breeding bird assemblage following the Abundance/Biomasse Comparisons (ABC) approach. A comparison of the ABC curves among fragments showed that the abundance curves never exceeded biomass curves. A partial overlap between the curves was found in the smaller fragments. Fragments with higher surface (> 4 ha) revealed a similar trend of both curves, showing a greater number of species with low abundance values. Larger fragments show strong differences in the abundance/biomass values of individual species, thus indicating that dominant species are characterized by high body weight impacting heavily on the energy balance of the area. Therefore, larger fragments are capable of supporting more species either in the space-level (more niche available for a greater number of species), or trophic-energetic level(more resources and more potential species with high body size and total biomass).

Introduction

In community ecology studies, there are many approaches of presenting species abundance data in a rank format, including e.g. diversity/dominance diagrams (named also Whittaker plots or rank/abundance diagrams; Whittaker 1965, Krebs 1999), abundance/biomass comparisons (or ABC curves; Warwick, 1986) and k-dominance plots (Lambshead et al. 1983, Platt et al. 1984; for a review, see Magurran 2004). These diagrams explicit the ratio of frequency (or dominance) among species, either calculated only on individuals (in diversity/dominance diagrams and in k-dominance plots) or on individuals and biomass contemporarily (in ABC curves). Therefore, these diagrams allow to get information on the species assemblages structure, e.g. in terms or their diversity or evenness. For example, under the k-dominance plot method more elevated curves represent the less diverse assemblages, while in ABC curves two measures of frequency are used, based either on individuals or on biomass. In this case, the relationships between the resulting curves are used to make inferences on the level of disturbance affecting the species assemblages. Indeed, in all these diagrams different slopes, shape and/or trend in curves furnish information on the stress suffered by assemblages (Magurran 2004, Benassi et al. 2007).

Among the various types of stress that a species assemblage linked to a specific habitat type can experiment there is the reduction in available area. Several previous studies, using the diversity/dominance diagram tool in a network of remnant fragments, confirmed that at fragment area decreases there is a corresponding increase in the slope of the diversity/dominance diagrams (for wood fragments, see Battisti et al. 2009). In this study we used the same set of data already processed by Benassi et al. (2007) for studying the level of stress experimented by an avian breeding assemblage following an alternative approach, that of the ABC curves. More explicitly, our aim is to test if the reduction in size area of wetland fragment could be considered a stress for the bird assemblage under study also under the ABC approach.

Materials and methods

Study area

The study was carried out in an archipelago of wetland fragments in the southwestern portion of the metropolitan area of Rome (Fiumicino, Cerveteri, and Ladispoli municipalities, Latium, Central Italy), along the Tyrrhenian coast. The wetlands were in a reclaimed flat plain (0-20 m a. s. l.), and were situated within a 40 km radius. The current landscape of the study area is severely altered, and is actually characterized by an agricultural anthropogenic habitat matrix that hosts fragment patches of natural and semi-natural ecosystems (remnant oak-woods and marshlands; Anon. 2006). The total surface of wetland fragments at landscape scale is very limited (< 1% on 400 kmq). Consequently, the effects linked to habitat fragmentation and area reduction are expected to act on bird communities and species (Andrén 1994, Fahrig 1997): for instance, for wetland-obligate bird species these remnants could be considered "habitat islands" and "geographically isolated wetlands" (Leibowitz 2003, Paracuellos 2006a, Benassi et al. 2009). Wetlands are characterized by reed-beds dominated by *Phragmites australis*, emergent plants like *Typha latifolia* L., and *Schoenoplectus palustris* L. (Palla), and isolated scrubs and trees such as *Quercus ilex* L., *Q. pubescens* Willd., *Populus alba* L., *Alnus glutinosa* (L.) Gaertner, *Fraxinus oxycarpa* (Willd.), *Salix alba* L., are also present (Ceschin and Cancellieri 2007). The climate is typically Mediterranean (mesomediterranean type, xeroteric region; Blasi 1994).

Protocol

A total of 16 marshland remnants (total area = 81.56 ha), ranging in size from 0.09 to 29.54 ha, were investigated (Table 1). Some of these fragments are included in the "Natural State Reserve of the Litorale Romano", and other fragments are listed as conservation concern areas (Special areas of Conservation; sensu "Habitat" 92/43/CE and "Birds" 79/409/CE Directives; Anon. 2007, Battisti et al. 2007, Benassi et al. 2007). This sample of fragments is highly representative, corresponding approximately to more than 75% of residual wetland coverage of the study area (Anon. 2006). The fragmented archipelago was distant from the nearby large non-fragmented marshlands (Circeo National Park) about 50-80 km. The frequency distribution of the fragments was highly skewed towards small fragments (< 1 ha). Remnants were selected from 1:10,000 scale maps and aerial photographs, and after preliminary field surveys. To determine area of the fragments, a Map-Info software (ArcView 3.2, ESRI, California) was used. A scarce variation occurs in the type and configuration of landscape surrounding the fragments that could be considered embedded in a similar matrix.

Table 1. Total size area (ATot in ha) of the 16 marshland fragments (Litorale romano, Rome, Central Italy).

Fragment	ATot
Muratella β	0.09
Magliana δ	0.11
Magliana β	0.12
Magliana γ	0.16
Magliana ε	0.16
Maglianaα	0.19
Macchiagrande	0.91
Muratella α	1.10
Fosso Zambra	1.24
Fosso Cadute	2.57
Foce Arrone	3.82
Spinaceto A	4.63
CHM	9.88
Torre Flavia	12.31
Spinaceto B	14.73
Vasche di Maccarese	29.54

In spring 2006, a survey was carried out in each fragment using the Territory Mapping Method (Pough 1947, Bibby et al. 1992), in order to obtain quantitative data on bird species richness (see International Bird Census Committee, 1969).

During the breeding season, many species of birds are territorial. Males sing to defend their territories and the boundaries between territories are often clearly defined by disputes with neighbouring birds. The breeding territory can thus readily be used as a census unit and territory mapping can be used as an effective census tool (Sutherland et al. 2004). The aim of territory mapping method is to determine how many breeding territories of each species do occur in a given study area. Although time-consuming, this method allows a relatively straightforward calculation of abundance, richness, and biomass in respect to other methods (Bibby et al. 2000).

The 16 remnants were visited early in the morning

Table 2. Cumulative percentages of the abundance (Cum Ab) and standing crop biomass (Cum Bb) data, ranked from the most to the least important in terms of either number of individuals or biomass, for the 19 species checked in the marshland fragments. Fragments with a single breeding species (Magliana ε, Magliana α) are omitted from this table.

	Muratella _		Magliana _		Magliana b		Magliana _		Macchiagrande		Muratella _		Fosso Zambra	
	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb
1	66,67	67,76	66,67	74,66	66,67	74,66	66,67	74,66	33,33	50,00	60,00	66,50	30,77	83,20
2	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	66,67	77,40	80,00	84,95	46,15	88,43
3									100,00	100,00	100,00	100,00	61,54	93,08
4													76,92	96,22
5													84,62	98,35
6													100,00	100,01
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														

	Fosso Cadute		Foce Arrone		Spinaceto A		CHM		Torre flavia		Spinaceto B		Maccarese	
	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb	Cum Ab	Cum Bb
1	36,84	51,95	37,50	70,84	24,66	45,04	37,10	35,47	36,08	50,86	9,92	60,11	29,86	58,06
2	68,42	70,93	62,50	84,45	41,10	60,43	53,23	66,31	48,45	75,11	19,83	75,33	44,24	85,82
3	89,47	84,46	75,00	90,84	50,68	72,16	62,10	77,09	58,76	90,57	29,75	84,06	56,47	91,55
4	94,74	92,64	83,33	94,38	58,90	82,34	70,97	86,42	69,07	92,92	38,02	90,86	66,55	93,24
5	100,00	100,00	87,50	96,42	67,12	91,08	79,03	94,19	79,38	95,22	46,28	92,30	72,30	94,83
6			91,67	97,97	71,23	93,05	85,48	96,39	87,63	96,61	54,55	93,33	77,34	96,14
7			95,83	99,41	73,97	94,88	91,13	98,34	91,75	97,60	62,81	94,30	82,01	97,03
8			100,00	100,00	76,71	96,14	92,74	99,37	93,81	98,57	69,42	95,26	86,33	97,67
9					79,45	97,36	94,35	99,59	95,88	99,12	74,38	96,20	89,21	98,09
10					82,19	98,17	95,97	99,77	96,91	99,38	79,34	96,85	91,37	98,51
11					84,93	98,69	97,58	99,89	97,94	99,62	84,30	97,44	92,81	98,84
12					87,67	99,15	99,19	99,95	98,97	99,85	88,43	97,97	94,24	99,11
13					90,41	99,32	100,00	100,00	100,00	100,00	90,08	98,38	95,68	99,38
14					93,15	99,49					91,74	98,77	96,40	99,58
15					94,52	99,63					93,39	99,16	97,12	99,76
16					95,89	99,76					95,04	99,45	97,84	99,87
17					97,26	99,87					96,69	99,72	98,56	99,94
18					98,63	99,94					98,35	99,89	99,28	99,97
19					100,00	100,00					100,00	100,00	100,00	100,00

during the breeding period (from March, 29 to June, 27). A single observer (G.B.) walked at a constant speed (1.0-1.5 km/h) along a previously established route in order to cover the whole area of each marshland fragment. Every remnant was surveyed eight times, always during good weather conditions and avoiding windy, misty, and rainy days (Bibby et al. 2000). The wetlands were visited in a random order.

Mapping was extended slightly outside the study area to ensure that the territory boundaries of species at the edge of the plot were recorded (Tomialojc 1980, Sutherland et al. 2004). For each fragment, mapping time was proportional to the study area size ($r_s = 0.963$, $P < 0.01$).

Every record (i.e., sign of bird territory occupancy) was plotted on a 1:2,000 scale map, following the guidelines of the standard territory mapping method. In our case, when eight visits were carried out, a cluster of at least three records is necessary to identify a territory (International Bird Census Committee 1969, Bibby et al. 2000).

We obtained a sampling map for each sampling day (i.e., visit). Finally, the whole data set was organised in species- specific maps. In each fragment, inside the eight visits, three samplings of an evident territorial behaviour were considered sufficient to document the existence of a breeding pair inside the fragment (International Bird Census Committee 1969, Bibby et al. 1992). We assigned a territory for each breeding pair (Bibby et al. 1992). Our methods did not permit the observation of species with crepuscular and nocturnal activity (e.g., Caprimulgiformes, Strigiformes).

Data analyses

For the species of the wetland fragments studied, we calculated an abundance index (total numbers of pairs) and standing crop biomass (Bb; Salt 1957), defined as the total weight of the individuals in the assemblage in g/10 ha.

Abundance and standing crop biomass data of the breeding species, expressed as percentage cumulative frequency, ranked from the most to the least important in terms of either number of individuals or biomass, along the × axis, are compared in the abundance/biomass curves (Abundance/Biomass Comparison or ABC curves; Warwick 1986). From the analyses, we omitted fragments with a single breeding species (Magliana α and Magliana ε in Table 1). Data at level of single species (abundance, biomass, frequency) subdivided for each fragment are available, if requested.

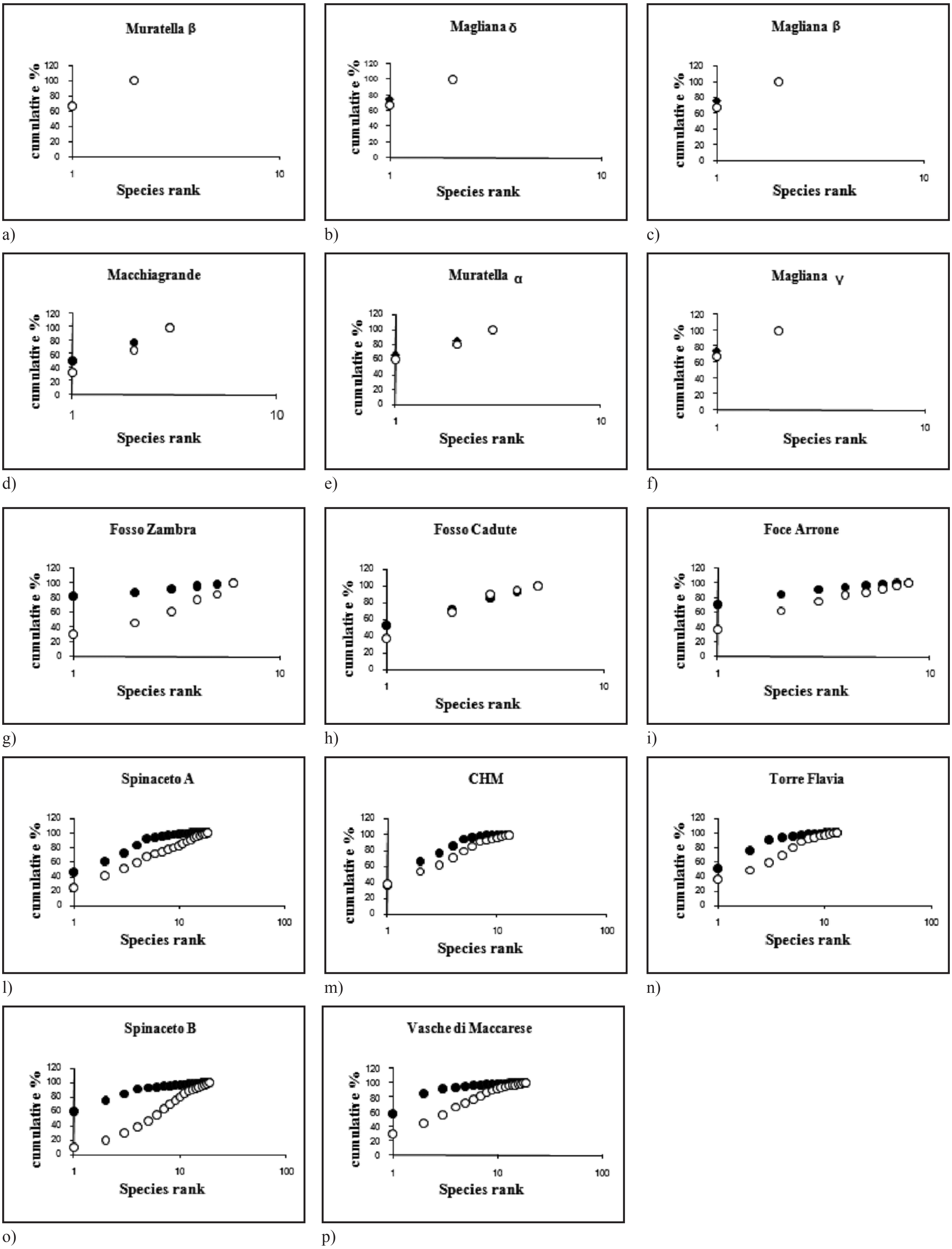
Results and discussion

A comparison of the ABC curves among fragments showed that the abundance curves never exceeded biomass curves (Fig. 1). Nonetheless, a partial overlap between the curves was found in the smaller fragments (i.e., Muratella β; Magliana δ, Magliana β and Magliana γ). Fragments with higher surface (> 4 ha, i.e. Spinaceto A, CHM, Torre Flavia, Spinaceto B, Maccarese) revealed a similar trend of both curves, showing a greater number of species with low abundance values (Fig. 1 l, m, n, o, p). The larger fragments (i.e., Vasche di Maccarese and Spinaceto B; Fig. 1 o, p) showed the most relevant difference between biomass and abundance values.

Analyzing ABC curves, interestingly we found diverging trends for fragments of different size. Although this is just an empirical evidence, it was clear that fragments < 1 ha showed trends of the curves to be more pronounced for the presence of few dominant species with small body weight (e.g., *Saxicola torquatus, Cettia cetti, Cisticola juncidis, Serinus serinus, Carduelis chloris, C. carduelis*). This pattern has already been described for highly disturbed assemblages, where the role of the landscape matrix has a relevant effect on the species checked, being usually ecologically generalists and mosaic species, small body weighed, and adaptable to altered environments (Andrén 1992, Andrén 1994, Schantz 1991, Bellamy et al. 1996). Instead, the fragments > 4 ha surface with relevant difference between biomass and abundance values of the species, showed an increase in the proportion of species with low frequency values but dominant in biomass (e.g., *Tachybaptus ruficollis, Ixobrychus minutus, Ardea purpurea, Anas platyrhynchos, Gallinula chloropus, Fulica atra*).

The fact that in ABC curves, the abundance curve did not overpass the biomass curve may be explained by the different role that the biomass and abundance species values do take at the community level. Frequency curves relative to the abundance (individuals) indicate a distribution of the spatial niche of the species; frequency curves relative to the biomass do indicate, on the contrary, the flow of energy in the assemblage according to the trophic resources used by species (Begon et al. 1986, Krebs 2001, Magurran 2004). Early-cumulating curves may indicate that the resources are used by few species with a broad spatial niche (e.g.., Spinaceto B, Vasche di Maccarese). Larger fragments show strong differences in the abundance/biomass values of individual species, thus indicating that a large set of species, also dominant, are characterized by high body weight impacting heavily on the energy balance of the area. Then, larger fragments are capable of supporting more species either in the space-level (more niche available for a greater number of species), or trophic-energetic level (more resources and more potential species with high body size and total biomass). This pattern is confirmed in our study, where wetland fragments larger than about 4 ha can allow the contemporary presence of more species and individuals with high body weight. Further research are however requested on this topic in order to bridging the gap between basic ecological parameters (e.g., richness, abundance and biomass) and conservation exigencies (e.g., minimum area requirement per sensitive assemblages).

Fig. 1 – ABC curves of the 14 selected wetland fragments: Muratella β (a), Magliana δ (b), Magliana β (c), Magliana γ (d), Macchiagrande (e), Muratella α (f), Fosso Zambra (g), Fosso Cadute (h), Foce Arrone (i), Spinaceto A (l), CHM (m), Torre Flavia (n), Spinaceto B (o), Vasche di Maccarese (p).
Along the axis ×, the species rank (log scale) from the most to the least important in terms of either number of individuals or biomass (n = 19) is reported; y axis displays the cumulative relative frequency calculated as a percentage for breeding species biomass (black dots) and abundance (white dots). Fragments with a single breeding species (Magliana ε, Magliana α) are omitted from this figure. Data at level of singles species and fragment are available, if requested.



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