Wetland selection, niche breadth and overlap in 10 duck species wintering in northern Campania (Italy)

Stefano Giustino[1], Marcello Bruschini[1], Elio Esse[1], Silvana Grimaldi[1], Danila Mastronardi[1], Silvia Capasso[1], Alessio Usai[1], Maurizio Fraissinet[1]*

Abstract - Analysis of the selection index, the niche breadth and the niche overlap of 10 species of wintering ducks in 11 wetland areas of the Campania region between January 2003 and 2015 revealed that the distribution of the species in the examined sites was not casual. In fact, each species actively chose their wintering area. Using selection index, we were able to measure the species' preferences and non-preferences for the 11 examined sites. By calculating Shannon-Wiener entropy and its normalized value (Evenness), we determined niche breadth; the Morisita index allowed us to check niche overlap.

Key words: wintering ducks, wetland selection, niche breadth, niche overlap, selection index, northern Campania.

Riassunto - Selezione, ampiezza e sovrapposizione della nicchia spaziale in 10 specie di anatre svernanti nella Campania settentrionale.

Utilizzando l'indice di selezione, l'ampiezza e la sovrapposizione di nicchia di 10 specie di anatre svernanti in 11 zone umide della Campania nel periodo compreso tra il gennaio 2003-2015, si è evidenziato come la distribuzione delle specie nelle zone umide esaminate non sia casuale. Le specie, infatti, scelgono attivamente il luogo in cui svernare. Utilizzando l'indice di selezione si sono potute misurare le preferenze e le non preferenze delle specie rispetto alle 11 località indagate. Attraverso il calcolo dell'entropia di Shannon-Wiener e del suo valore normalizzato (Evenness) è stata calcolata l'ampiezza di nicchia spaziale, mentre utilizzando l'indice di Morisita si è potuto verificare la sovrapposizione della stessa.

Parole chiave: Svernamento anatre, Selezione delle zone umide, ampiezza e sovrapposizione della nicchia spaziale, indice di selezione, Campania settentrionale.

INTRODUCTION

The monitoring of wintering ducks has greatly increased in Italy over the last two decades and has led to an increase in publications on trends in individual species (Bon *et al*., 2005; Guzzon *et al*., 2005; Arcamone *et al*., 2007; Brunelli *et al*., 2009; Fraissinet & Cavaliere, 2009; Tinarelli *et al*., 2010; Pedrini, 2011; Bon & Scarton, 2012; Saporetti & Carabella, 2012; Zenatello *et al*., 2014; Fraissinet *et al*., 2014). However, there are still too few papers on birds as environmental indicators for us to determine community indices (Boldreghini & Dall'Alpi, 2005; Virdis *et al*., 2005; Bon & Scarton, 2012; Longoni *et al*., 2014). Here, we provide an analysis of the wintering of 10 wild ducks species in Campania, determining which species has the widest niche breadth and which has the greatest niche overlap. Our findings support the hypothesis that the choice of wintering area is active rather than casual. We also provide a quantitative, predictive and inductive basis for improving wetland management and planning for environmental preservation.

[1] ASOIM Onlus - Associazione Studi Ornitologici Italia Meridionale, Via Cavalli di Bronzo 95, 80046 San Giorgio a Cremano (NA), Italia.

* Corresponding author: mfraissinet@tiscali.it

Received: 25 January 2016
Accepted for publication: 10 September 2017

Study area

The northern part of the Campania Region is made up by the Caserta Province, which extends over 263,900 hectares (corresponding to 652,111 acres). It is constituted by alluvial plains created by the rivers Volturno and Garigliano, it is mainly formed by plains with isolated mountains and hills such as Tifatini Mountains, Mount Maggiore and Volcano of Roccamonfina. However, going inland, we find hills which become gradually higher and then suddenly give room to high mountains with the Apennine chain of the Matese mountains, which marks the border with the Molise Region. ISPRA (the Italian National Institute for Environmental Protection and Research) has identified and codified 20 wetlands (Baccetti & Serra, 1994 and following updates), but only 10 resulted suitable for wintering ducks, which regularly visit those. Two macroareas can be identified: Apennine and Subapennine wetlands, including 6 wetlands, and Litorale Domitio (Domitia Coast), located at sea level, including 3 wetlands, among which Lago Patria (Patria Lake), in the Province of Naples. Because of its proximity to the wetlands of Caserta coast, it completely falls into this macroarea. A couple of sites don't fall into these two macroareas, since they are located on the Volturno river plain. Here follows a synthetic description of the examined wetlands with specific sites detected for each wetland. In Fig. 1 you can view their position on the territory. Hunting is banned on all sites.

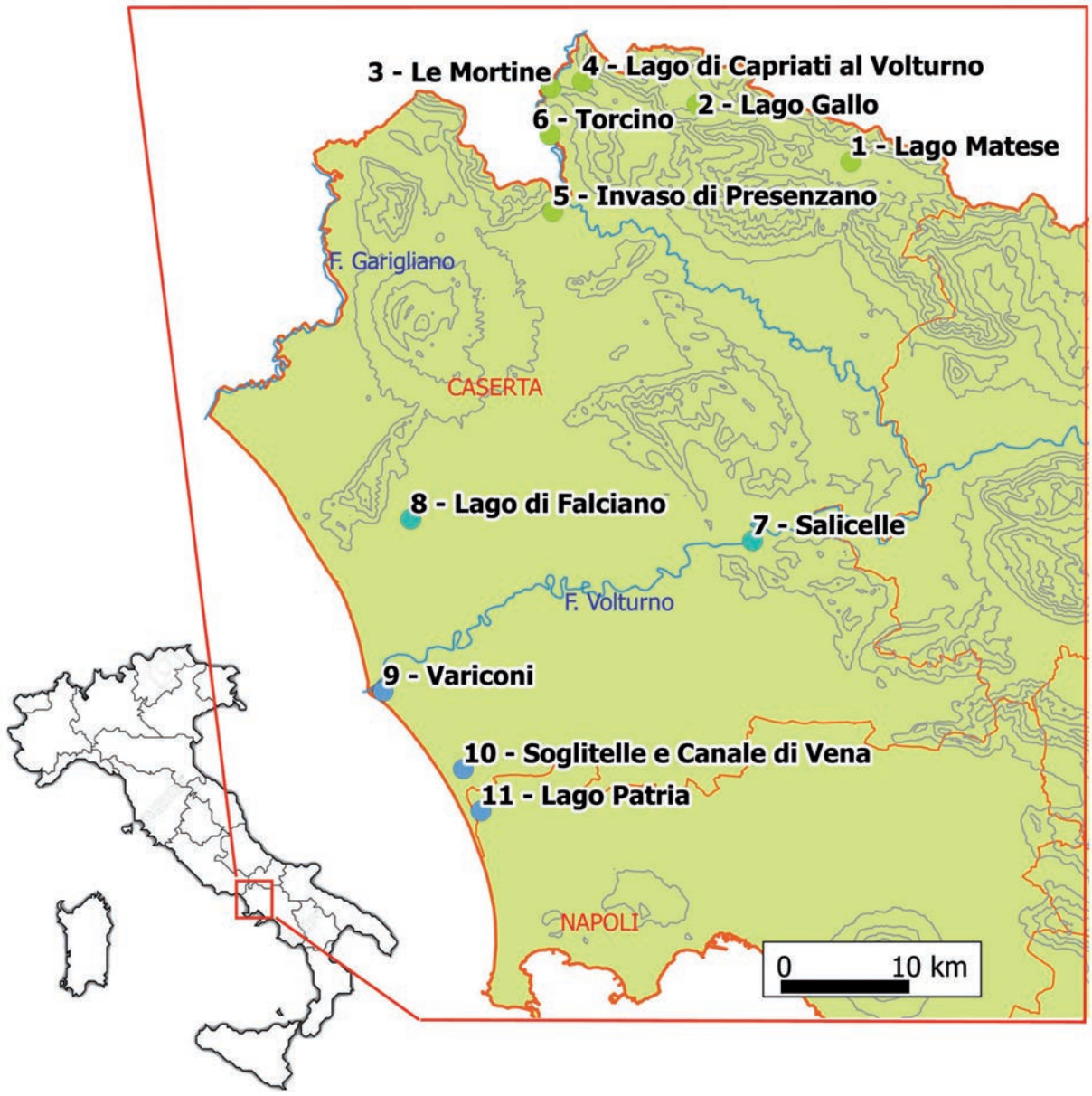

Fig. 1 - Localization of examined wetlands. / Localizzazione delle località indagate.

Apennine and Subapennine Macroarea

1. Lago Matese (Matese Lake, 1011 m. a.s.l., 453 ha) - Karst lake, subject to water regulating measures. It's surrounded by grasslands, reedbeds, pastures and beech woods. It's monitored through 16 observation points.
2. Lago Gallo (Gallo Lake, 870 m. a.s.l., 68 ha) - Reservoir built along the Sava river. It's mainly surrounded by grasslands. In a few spots there are small reedbeds, willow woods and riparian poplars. It's monitored through 5 observation points.
3. Le Mortine (160 m. a.s.l., 12.5 ha) - Reservoir obtained through an ENEL embankment (ENEL is an Italian electricity supplier), it was built in the'50s, along the Volturno river. It includes willow and poplar woods, which become partially flooded in some periods of the year. It's monitored through 3 observation points.
4. Lago di Capriati al Volturno (Lake of Capriati al Volturno, 184 m. a.s.l., 12.8 ha) - Small artificial basin built for energy supply. It has got cemented riverbanks, which recently started to be covered with willows and common reed. For the aim of this study, a single observation point has been sufficient.
5. Invaso di Presenzano (Presenzano Reservoir, 270 m. a.s.l., 69.6 ha) - Artificial basin with cemented banks and no vegetation. It's monitored through 3 observation points.
6. Torcino (172 m. a.s.l., 26.5 ha) - It's formed by two artificial basins, following the extraction of gravel material from the bed of the Volturno river. It's part of a large farming area and it's monitored through 2 observation points.

Macroarea of the Litorale Domitio (Domitia Coast)

9. Variconi (38.8 ha) - Brackish ponds behind the dunes, located along the Caserta coast, near the mouth of the Volturno river. They are separated from the sea by a sandy beach and they feature reedbeds, tamarisk groves, rush and glasswort marshlands. They are monitored through 9 observation points.
10. Soglitelle and Canale di Vena (99.7 ha) - Basins and swamps located in a territory characterized by intensive livestock and agricultural activities, near an irrigation canal. It's monitored through 11 observation points.
11. Lago Patria (Patria Lake, 221.1 ha) - Brackish water lagoon of volcanic origin. Its banks are partly natural and partly artificial. This site features willows, reedbeds and grasslands. It's monitored through 9 observation points.

Outside the Macroareas

7. Salicelle (26.5 m. a.s.l., 25 ha) - Reservoir located along the Volturno river, with banks surrounded by willows, fruit trees and reedbeds. It's monitored through 3 observation points.
8. Lago di Falciano (Falciano Lake, 10 m. a.s.l., 8.5 ha) - Small lake whose banks are surrounded by willows and reedbeds. It's surrounded by a large farmland, with fruit and vegetable cropping. There are 2 observation points for census surveys.

MATERIALS AND METHODS

Sampling protocol

In the 11 examined wetlands, during the months of January of the years 2003-2015, counting has been carried out from 64 observation points, which so far have remained unchanged. The observation points were chosen based on opportunistic criteria, therefore some spots were chosen because they were easy to reach and offered a wide view of water surface, allowing a complete overall view of each wetland. Counting was done using 20-60× telescopes during the central weeks of January, corresponding to the periods indicated by IWC for the wintering waterbird census.

In order to avoid double counting, in the last few years monitoring has been carried out contemporarily in different wetlands.

Only 10 species of regularly wintering ducks, on site for at least 9 consecutive years, have been considered: Common Shelduck (*Tadorna tadorna*), Eurasian Wigeon (*Anas penelope*), Gadwall (*A. strepera*), Common Teal (*A. crecca*), Mallard (*A. platyrhynchos*), Northern Pintail (*A. acuta*), Northern Shoveler (*A. clypeata*), Common Pochard (*Aythya ferina*), Ferruginous Duck (*A. nyroca*) and Tufted Duck (*A. fuligula*).

Data analysis

In order to support and check the hypothesis that ducks actively chose their wintering wetland, we used the selection index with its respective 95% confidence interval (Manly *et al*., 1993), which consists in comparing the site use ratio for each single species (N. individuals in the area / N. total individuals) to the availability ratio of a specific site, with regard to its surface, compared to the total surface of the site. The abundance of single species has been considered by summing it up for all years of the research period. As for the confidence intervals, the Bonferroni correction was applied, in order to keep constant the error of the first kind (α). For the niche breadth, the descriptive Shannon - Wiener Entropy (H') index was used, as well as its normalized value, Equitability $J = H'/H'_{max}$ (Margalef, 1958; Cazzolla Gatti, 2014). The Morisita descriptive index (Morisita, 1959), was used to measure the overlap level of niches among the species. It is based on the resource use ratio (N. individuals in the area / N. total individuals) for each specific site.

RESULTS

Tab. 1 reports lower and upper limits of 95% confidence interval of selection index, intended as preference, non-preference, random and absence measures. It can be noticed that Common Teal, Mallard, Common Pochard and Tufted Duck are more ubiquitous than other species. On the other hand, Northern Shoveler and Common Shelduck are very selective and they prefer a specific wetland. The Eurasian Wigeon prefers wetlands with large water surfaces, while diving ducks – Common Pochard, Tufted Duck and Ferruginous Duck – show a strong preference for the Mortine wetland, which results in very high values. The most popular wetland is the Variconi coastal ponds, which is preferred by 9 species out of 10. Finally, it must be specified that this Table doesn't only indicate the most favourite wetlands by species, but it measures their preference.

In Tab. 2 are reported the niche breadth measures of the species in all sites, using the Shannon-Wiener H' index and the Equitability $J = H'/H'_{max}$. It's important to highlight that different species of ducks have very different niche breadth, going from the less demanding Mallard, Common Pochard, Common Teal and Tufted Duck, which are quite common, to the very demanding species: Ferruginous Duck, Common Shelduck, Gadwall and Northern Shoveler.

In Tab. 3 are reported the overlap measures of all species in all sites. You can notice that the Common Shelduck is a species with a low niche overlap compared to other species, because it visits different wetlands compared to other duck species.

DISCUSSION

Our data (Tab. 1) gives evidence that the 10 duck species examined actively choose their resting areas during the wintering period. Indeed, our analysis confirms that the heterogeneity of wintering sites is due to the different ecological needs of each species. For example, diving ducks definitely prefer the Mortine area, while the Common Shelduck and Northern Shoveler are very selective and show a strong preference for specific sites, the former preferring the flooded basins and swamps

Tab.1 - Selection index and 95% confidence interval. Values in bold = Prefers; Values in italic = Not prefers; Values underlined = Indifferent. / / Indice di selezione e intervallo di confidenza al 95% Caratteri in grassetto = preferisce; in italico =non preferisce; sottolineato = indifferente

	Eurasian Wigeon		**Gadwall**		**Common Teal**		**Mallard**	
Site	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Variconi	**2.25**	**3.08**	**20.99**	**23.21**	**7.83**	**8.39**	**1.16**	**1.54**
Le Mortine	0.62	1.61	**3.53**	**8.22**	**13.69**	**15.13**	**20.05**	**22.40**
Presenzano	*0.25*	*0.49*			**1.28**	**1.47**	**1.59**	**1.90**
Lago Gallo					*0.04*	*0.08*	*0.31*	*0.47*
Lago di Falciano	0.00	0.66			**5.59**	**6.81**	*0.02*	*0.30*
Salicelle	*0.01*	*0.26*	*-0.12*	*0.49*	**1.81**	**2.22**	*0.20*	*0.44*
Soglitelle - Canale di Vena					*0.00*	*0.02*	*0.00*	*0.03*
Lago Matese	**1.16**	**1.28**	*0.00*	*0.05*	*0.66*	*0.71*	*0.72*	*0.79*
Torcino	*-0.02*	*0.05*			*0.01*	*0.07*	**2.65**	**3.33**
Lago di Capriati					0.88	1.31	**8.47**	**10.14**
Lago Patria	**1.40**	**1.62**	*0.26*	*0.55*	*0.04*	*0.07*	*0.06*	*0.10*
	Northern Pintail		**Northern Shoveler**		**Common Pochard**		**Tufted Duck**	
Site	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Variconi	**11.59**	**18.07**	**19.59**	**23.01**	**3.60**	**4.38**	**2.72**	**4.20**
Le Mortine	0.13	9.69	0.00	0.00	**24.92**	**28.09**	**32.51**	**39.30**
Presenzano	*-0.22*	*0.66*	*-0.09*	*0.18*	*0.14*	*0.28*	*0.30*	*0.76*
Lago Gallo					**1.40**	**1.78**	**2.95**	**4.00**
Lago di Falciano								
Salicelle					*-0.02*	*0.07*		
Soglitelle – Canale di Vena	**2.55**	**4.99**						
Lago Matese			*-0.01*	*0.08*	*0.13*	*0.18*	0.03	0.09
Torcino					*0.51*	*0.94*	*0.09*	*0.77*
Lago di Capriati					**15.96**	**18.68**	**3.28**	**6.46**
Lago Patria	*-0.06*	*0.13*	0.57	1.15	*0.46*	*0.58*	*0.25*	*0.45*
	Ferruginous Duck		**Common Shelduck**					
Site	Lower	Upper	Lower	Upper				
Variconi	**7.08**	**13.75**	-0.08	1.22				
Le Mortine	**37.35**	**58.29**						
Presenzano			*-0.09*	*0.51*				
Lago Gallo	*-0.23*	*0.47*						
Lago di Falciano								
Salicelle								
Soglitelle - Canale di Vena			**6.68**	**8.26**				
Lago Matese								
Torcino	-0.63	1.90						
Lago di Capriati	-1.20	2.52						
Lago Patria			0.81	1.49				

Tab. 2 - Shannon-Wiener H' Index and Equitability J of the species, regarding all sites. / Indice di Shannon - Wiener H' ed Equitabilità J delle specie, riferito a tutte le località.

	H'	J
Mallard	1.785	0.744
Common Pochard	1.775	0.740
Common Teal	1.691	0.705
Tufted Duck	1.584	0.661
Eurasian Wigeon	1.118	0.466
Northern Pintail	0.961	0.401
Ferruginous Duck	0.783	0.326
Common Shelduck	0.725	0.302
Gadwall	0.627	0.262
Northern Shoveler	0.574	0.240
H'_{max}	2.398	

of Soglitelle-Canale di Vena, and the latter preferring the brackish ponds of Variconi. Shannon–Wiener indices, equitability (Tab. 2) and the Morisita overlap index (Tab. 3) all comply with previous results: they show the heterogeneity of species at the sites, and different degrees of niche overlap. This confirms what has already been observed at the qualitative level over the last few years: ducks do not distribute equally in the examined sites, possibly because they prefer different habitats, with different habitats likely attracting different species. The level of attraction should be evaluated in the future so that it may be applied to conservation and reproduced at other sites.

By measuring the preference of various species for different types of wetland, we have highlighted the great importance of conserving each one. In fact, the vulnerability of a species depends not only on its numerical relevance but also on its ecological preference, which can be more or less extensive (Primack, 2000).

Tab. 3 - Morisita's Overlap Index. / Indice di sovrapposizione spaziale di Morisita.

	Eurasian Wigeon	Gadwall	Common Teal	Mallard	Northern Pintail	Northern Shoveler	Common Pochard	Tufted Duck	Ferruginous Duck
Gadwall	0.2133								
Common Teal	0.6356	0.5813							
Mallard	0.6339	0.1434	0.7870						
Northern Pintail	0.1407	0.8171	0.5436	0.1404					
Northern Shoveler	0.2755	0.9898	0.5579	0.1119	0.8017				
Common Pochard	0.3068	0.3498	0.5999	0.7043	0.3228	0.3244			
Tufted Duck	0.1748	0.3002	0.5223	0.6092	0.2795	0.2513	0.8820		
Ferruginous Duck	0.1062	0.6173	0.6197	0.4910	0.5447	0.5410	0.7229	0.8099	
Common Shelduck	0.1676	0.0609	0.0284	0.0208	0.5408	0.0996	0.0793	0.0512	0.0158

REFERENCES

Arcamone E., Dall'Antonia P. & Puglisi L., 2007 − Lo svernamento degli uccelli acquatici in Toscana. 1984-2006. *Edizioni Regione Toscana*.

Boldreghini P. & Dall'Alpi A., 2005 − Gli uccelli acquatici nella Laguna di Comacchio: uso dello spazio trofico in un'area antropizzata. In: Avifauna acquatica: esperienze a confronto. Atti del I Convegno (30 aprile 2004). *Tipografia Giari*, Codigoro: 49-53.

Bon M. & Scarton F., 2012 − Lo svernamento degli uccelli acquatici in provincia di Venezia (1993-2012). *Assessorato alla Caccia Ed*., Venezia.

Bon M., Boschetti E. & Verza E., 2005 − Gli uccelli acquatici svernanti in provincia di Rovigo. *Provincia di Rovigo,* Rovigo.

Brichetti P. & Fracasso G., 2003 − Ornitologia italiana. Vol. 1. *Alberto Perdisa editore*, Bologna.

Brunelli M., Corbi F., Sarrocco S. & Sorace A. (a cura di), 2009 − L'avifauna acquatica svernante nelle zone umide del Lazio. Edizioni ARP (Agenzia Regionale Parchi), Roma. *Edizioni Belvedere*, Latina.

Cazzolla Gatti R., 2014 – Biodiversità in teoria e pratica. *Libreriauniversitaria.it*, Padova.

Chedzoy O. B., 2006 – Encyclopedia of statistical sciences. *John Wiley & Sons*, New York.

Fraissinet M., Bruschini M., Esse E., Grimaldi S., Giustino S., Mastronardi D., Piciocchi S., Tatino F. & Usai A., 2014 – Andamenti delle anatre svernanti nelle zone umide della Provincia di Caserta nel periodo 2003-2014. *Picus*, 40: 109-118.

Guzzon C., Tout P. & Utmar P. (eds.), 2005 – I censimenti degli uccelli acquatici svernanti nelle zone umide del Friuli Venezia Giulia, anni 1997-2004. Associazione Studi Ornitologici e Ricerche Ecologiche del Friuli Venezia Giulia (A.ST.O.R.E. - FVG). *Centro Stampa di A. Candito & F. Spagnero Snc.,* Monfalcone.

Krebs J. K., 1999 – Ecological Methodology. *Addison Wesley Longman*, New York

Longoni V., Rubolini D., Pinoli G. e Fasola M., 2014 – Andamento delle popolazioni di uccelli acquatici svernanti in Lombardia 2002-2013. *Rivista Italiana di Ornitologia - Research in Ornithology*, 84: 3-66.

Manly B.F.J., Mc Donald L.L. & Thomas D.L., 1993 – Resource selection by animals: statistical design and analysis for field studies. *Chapman and Hall*, London.

Margalef D.R., 1958 – Information theory ecology. *General Systems*, 3: 36-7.

Morisita M., 1959 – Measuring of interspecific association and similarity between communities. *Memoirs of the faculty of science Kyushu University*, *Series E,* 3: 65-80.

Pedrini P. (a cura di), 2011 – Gli uccelli acquatici svernanti in Trentino. *Museo delle Scienze*, Trento.

Primack R.B., 2000 – A primer of conservation Biology. *Sinauer Associates Inc.,* Sunderland. Trad. Ita. 2003. Conservazione della natura. *Zanichelli ed.*, Bologna.

Saporetti F. & Carabella M. (a cura di), 2012 – Uccelli acquatici svernanti. 25 anni di dati in Provincia di Varese. *Quaderni del Gruppo Insubrico di Ornitologia*, 1.

Tinarelli R., Giannella C. & Melega L. (a cura di), 2010 – Lo svernamento degli uccelli acquatici in Emilia Romagna: 1994-2009. Regione Emilia-Romagna e AsOER ONLUS. *Tecnograf. ed.,* Reggio Emilia.

Virdis F., Magnani A. & Serra L., 2005 – Gli uccelli acquatici come indicatori ambientali per la gestione eco-compatibile del turismo nella salina di Cervia. In: Avifauna acquatica: esperienze a confronto. Atti del I Convegno (30 aprile 2004). *Tipografia Giari*, Codigoro: 40-48.

Zenatello M., Baccetti N. & Borghesi F., 2014 – Risultati dei censimenti degli uccelli acquatici svernanti in Italia. Distribuzione, stima e trend delle popolazioni nel 2001-2010. Serie Rapporti 206/2014. *ISPRA*, Ozzano Emilia.

Supplementary table - Cumulative Abundance over 13 years on the 11 sites. / Abbondanza cumulativa per 9 13 anni negli 11 siti.

Species / Site	Eurasian Wigeon	Gadwall	Common Teal	Mallard	Northern Pintail
Variconi	296	549	4653	389	75
Le Mortine	40	47	2663	1969	8
Presenzano	74	0	1414	902	2
Lago Gallo	0	0	57	198	0
Lago di Falciano	8	0	779	10	0
Salicelle	10	3	745	59	0
Soglitelle	0	0	14	11	49
Lago Matese	1581	7	4576	2537	0
Torcino	1	0	15	588	0
Lago di Capriati	0	0	208	884	0
Lago Patria	957	57	183	138	1
Total	**2967**	**663**	**15307**	**7685**	**135**

Species / Site	Northern Shoveler	Common Pochard	Tufted Duck	Ferruginous Duck	Common Shelduck
Variconi	253	719	153	48	6
Le Mortine	0	1538	511	71	0
Presenzano	1	67	42	0	4
Lago Gallo	0	501	269	1	0
Lago di Falciano	0	0	0	0	0
Salicelle	0	3	0	0	0
Soglitelle	0	0	0	0	202
Lago Matese	5	326	32	0	0
Torcino	0	89	13	2	0
Lago di Capriati	0	1029	71	1	0
Lago Patria	58	535	88	0	69
Total	**317**	**4807**	**1179**	**123**	**281**