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EFFECT OF SPRING WATER STRESS INDUCED BY FISHERY FARMING ON TWO DUCK SPECIES ANAS PLATYRHYNCHOS L. AND ANAS CRECCA L. IN A MEDITERRANEAN WETLAND

ABSTRACT: In a remnant wetland of Central Italy, we assessed the effect of water level changes induced by fishery farming activities (February–July) on the abundance of two duck species (mallard, Anas platyrhynchos and teal, A. crecca) during a two-years period: a “treatment” year (2004) when fishery farm activity was high and water level dropped, and a “control” year (2007) when it was inactive and water level increased. Abundance values of mallards and teals were significantly different in the two years, and showed a direct correlation with water level in both the species in 2004 but not in 2007. In both species, abundance was significantly lower in 2004, only in late spring (June–July), revealing their sensitivity to water stress. A higher water level in wetland in control year 2007 may favour teals and mallards in the study area, allowing respectively the permanent occurrence of the former (a locally wintering species) and a higher abundance of the latter (locally breeding and resident species). A higher water level in wetland channels with the flooding of the surrounding reed- and rush beds, may induce a larger area of suitable habitat, available for these duck species. These facts emphasized that water level changes due to human activities are key to year-to-year variation in duck abundance in Mediterranean wetland region.

KEY WORDS: remnant wetland, Anas platyrhynchos, Anas crecca, fishery farming, water stress, Mediterranean.

Water stress is a complex disturbance affecting biodiversity and ecological processes, which can vary in frequency, intensity and duration. Moreover, effects of water stress on biodiversity change with the season and an abrupt water level change could produce more or less severe impact on water-related birds if it occurs in different times of their life cycle (e.g., during wintering or breeding period) (Kushlan 1986).

In Mediterranean region, fishery farming of mullet fry (Mugil spp.) is an economic activity that produces water level fluctuations in wetlands (Marino et al. 1998). The water level can change quickly in spring, when mullet fry are harvested (Battisti et al. 2006). These fluctuations may become a severe disturbance on assemblages of water-related birds occurring in these ecosystems.

Waterfowls and waders comprise a large set of water-related species with different phenology and strictly linked to specific water regimes (Battisti et al. 2006, Boertmann and Ricet 2006, Holm and Clausen 2006,
Among waterfowl, ducks (Anseriformes Anatidae) are a group of species that are particularly sensitive to water level changes (Nummy and Pöysä 1995, Austin 2002, Krapu et al. 2006). Nevertheless, relatively little is known regarding the response of these species to wetland habitat alteration caused by anthropogenic manipulation of hydrologic cycle (Steen et al. 2006), at least in Mediterranean region (Ashkenazi and Dimentman 1998, Shy et al. 1998).

In a Mediterranean wetland of central Italy, we carried out several research on this topic, assessing the role of water level changes on different bird species and assemblages (e.g., passeriformes, rallidae) in different seasons (Battisti et al. 2006, Causarano and Battisti 2009, Causarano et al. 2009). Following this approach, the aim of this study is to evaluate the effects of water stress induced in late spring by fishery farm on two ducks, the mallard (Anas platyrhynchos L.) and the teal (A. crecca L.), which are the more abundant species of a remnant coastal wetland area. To assess the effect of water stress on these birds, we compared the duck abundance with water level data recorded during a two years-period: a “treatment” year (2004) when fishery farm activity was high and water level dropped, and a “control” year (2007) without fishery farm activity, characterized by an elevated water level in a network of wetland channels.

The study area is the “Palude di Torre Flavia” (41°58’N; 12°03’E; Special Area of Conservation according to the EU Directive 79/409), a nature reserve consisting of a coastal wetland 40 ha large, located on the Tyrrhenian seashore (Central Italy). From a bioclimatic point of view, the area belongs to the meso-Mediterranean xeric region (Tommaselli et al. 1973, Blasi and Michetti 2005) and represents a relict of a larger wetland, partially drained and transformed in the last fifty years, where water is mainly of meteoric and sea storm origin. Flow from surrounding areas is scarce. Water level varies with the seasons: from October to March the flood level reaches the maximum value (120 cm), while from June to October is reduced to form some areas of muddy soil or shallow ponds (Battisti et al. 2006; seasonally flooded wetland sensu Cowardin et al. 1979).

The study area shows a specific, seminatural patchiness (Malavasi et al. 2009), composed by different patches of reed beds, dominated by Phragmites australis (Cav.) Trin ex Steudel, and by rush beds dominated by Juncus sp. and Carex sp. (Juncetalia maritimi: habitat type of conservation concern; 92/43 “Habitat” EU directive). This vegetation is cut off by water basins as ponds and channels (approximately 2,850 m long) used for fish farming of mullets, as Mugil cephalus (L.), Liza ramada (Risso), Liza saliens (Risso). Fish farming affects the biological cycle of many avian species, also inducing a water stress and
others impacts on specific ecosystem components (Battisti et al. 2004, 2006, 2008).

Water level is variable in space and in time. Around a yearly cycle, water level is the maximal inside the channels from October to April. A progressive drought period occurs between May and September in rush and reed beds. This summer drought is typical of the meso-Mediterranean xeric region (Tomaselli et al. 1973, Blasi 1994, Blasi and Michetti 2005). In the years when fishery farm is active, the water level dwindles abruptly in April, either in channels, or in rush and reed beds. Subsequently, between May and September, the whole wetland (i.e., channels, rush beds and reed beds) tends to dry out (Battisti 2006). During this study, in 2004 the fishery farm was active and water level dropped (“treatment” year), while in 2007 the farm did not work and the spring level water was elevated (i.e., higher than 120 cm in channels) (“control” year).

To assess water level in channels we used a metric pole (+/-1 cm), once each visit. We performed a total of 36 visits from February to July in two years (2004 and 2007; see below). Channels were artificially built for fish farming in the first half of 20th Century and have the same depth along their course. Consequently, water level measured at each sampling session is representative of local fish farming activity. For each year, we organized water level data in three two-month periods, giving a mean value and standard deviation for each period.

The transect method with direct-count (Jarvinen and Vaisannen 1975, Bibby et al. 2000) was used to study the abundance of two duck species (mallard, Anas platyrhynchos and teal, Anas crecca) in “Torre Flavia” wetland, between February and July, during two years of contrasting water level. Evidence from previous studies (e.g. Blondel 1969) showed that direct-count method is the most suitable for studying changes in seasonal abundance. This method provides data on bird localization in the wetlands and allows an overall estimate of their abundance (Parracuellos 2006).

Data were collected by one observer who surveyed the transect for about three hours (07.00–10.00 a.m.), walking with an approximately speed of 1.5 km h⁻¹. The length of the transect, representative of the entire wetland area, was about 2,500 m. During each survey, the observer recorded all the adult ducks seen along the transect. Records were reported on a 1:2,000 map. Only two species (Anas platyrhynchos and Anas crecca), i.e. the most locally abundant species, were used for this study. Other observed duck species were the wigeon Anas penelope L., the showeler A. clypeata L., the garganey A. querquedula L., and the ferruginous duck Aythya nyroca (Güldenstädt).

The two duck species considered in this study have a medium-large body size and

![Mean values of abundance (SD) of Anas platyrhynchos measured as number of individuals noted along 2,500 m long transect through the study wetland (40 ha) in each two-month periods of two years of contrasting water level (see Fig. 1). Black columns: 2004 (fish farming active); white columns: 2007 (fish farming inactive). Jun-Jul = sig. change (P <0.01).]
were easily detected in vegetation structure of the study landscape (open habitats and patchy rush/reed beds). For this reason, it was assumed that direct counts had a high level of accuracy (see Bibby et al. 2000).

For each year, in February–July sampling period, we carried out 36 visits (108 hours per year of total sampling). As for water level measures, counting data for each species and visit were organized in three two-month periods (February–March, April–May and June–July), giving a mean value and standard deviation for each species per year. Counts were made under favourable environmental conditions (without rain or strong wind). Observer used a binocular 10 × 42.

For each visit, we compared the water level in the channels with the abundance of *Anas platyrhynchos* and *Anas crecca*, performing the Spearman rank correlation test (two-tailed). We performed the Mann-Whitney U-test to compare the median values of water level in each two-month period of two years of contrasting water level. Moreover, the Kruskal-Wallis was used to test the differences in the median values of abundance among the three two-month periods for each year. We performed all statistical analyses using SPSS version 13.0 (SPSS Inc. 2003). We assumed 5 and 1% as alpha levels.

Mean water level in the study area ranged about 20–120 cm in 2004, and about 90–120 cm in 2007 (Fig. 1). In 2004 June–July period, water level was significantly lower than in the same period of 2007 (Z = –2.887; *P* = 0.004; Mann-Whitney U test). Differences among the three two-month periods were significant only in 2004 (H = 3.971; *P* = 0.004; Kruskal-Wallis test) (Fig. 1).

Abundance values of *Anas platyrhynchos* significantly differ during the study period either in 2004 (H = 26.223, *P* = 0.000; Kruskal-Wallis test, df = 11) or in 2007 (H = 8.759; *P* = 0.042; Kruskal-Wallis test, df = 11) (Fig. 2). Also in *Anas crecca*, abundance values significantly differ either in 2004 (H = 31.700, *P* = 0.000; Kruskal-Wallis test, df = 11) or in 2007 (H = 22.934; *P* = 0.042; Kruskal-Wallis test, df = 11) (Fig. 3).

Abundance values of both species showed a direct correlation with water level in 2004 (*Anas platyrhynchos*: *r* = 0.861, *P* = 0.000; *Anas crecca*: *r* = 0.812, *P* = 0.000), but not in 2007 (*Anas platyrhynchos*: *r* = –0.051, *P* = 0.841; *Anas crecca*: *r* = –0.070, *P* = 0.790).

Average abundance values of *Anas platyrhynchos* and *Anas crecca* were significantly different (or tend to) between years but only in June–July (lower in 2004) (respectively, Z = –2.678; *P* = 0.007 and Z = –1.892; *P* = 0.059, Mann Whitney U test).

![Fig. 3. Mean values of abundance (SD) of *Anas crecca* measured as number of individuals noted along 2,500 m long transect through the study wetland (40 ha) in each two-month periods of two years of contrasting water level (see Fig. 1). Black columns: 2004 (fish farming active); white columns: 2007 (fish farming inactive).](image-url)
In Mediterranean Central Italy, late spring represents a period where water level of wetlands changes abruptly owing to hot and dry climatic conditions (summer drought, cf. Blasi and Michetti 2005). This progressive water level decrease is emphasized in our study area because of fishery farm activities carried out in spring. Indeed, in June–July of fish farming year (2004), water level was significantly lower when compared to the same period of 2007, when there was any fish farming activity and the water level was maintained elevated all over the spring. This significant decrease, reduced the suitability of wetland habitats (channels, reed beds, rush beds) for water-obligated species, with effects on their occurrence and abundance.

In 2004, abundance of both the species showed a direct correlation with water level in the channels: a higher level of water (observed in February) promoted the permanence in the late spring of mallard duck, a locally sedentary breeding species, and the delay of a migratory stock of the teal, a locally wintering species (Battisti et al. 2006). A comparison between the two years, 2004 and 2007, showed that abundance values of the mallard were significant lower in June–July of the former year, when fishery farm was active and a consequent water stress occurred in late spring. These data revealed a sensitivity of the mallard to water stress as highlighted by several authors in northern countries (Ashkenazi and Dimentman 1998, Boerkmann and Ricet 2006, Connor and Gabor 2006, Holm and Clausen 2006, Steen et al. 2006).

The abundance of teals between two years periods showed an evident difference only in June–July. This duck was absent in spring (April) of 2004 while in 2007 occurred until July. These data corroborated the hypothesis that a suitable water level management (i.e. in this case, higher water level in channels and, consequently, in surrounding rush- and reed-bed) may increase the occurrence and abundance of this species (Boerkmann and Ricet 2006), allowing the permanent occurrence of this wintering species, at least in Mediterranean area. Teal is a duck that prefers wetland habitats with water level ranging between 20–30 cm (Pöysä 1983). In our study, in 2007 the rush-beds surrounding the channels were flooded and the water level was comprised in this range.

A higher water level in channels with a flooding of surrounding reed- and rush beds, may induce a larger area of suitable habitat available for water-related species, suggesting that wetland habitat conditions (i.e., increase of availability of areas with suitable water level) were key to year-to-year variation in abundance for these ducks (Cowardin et al. 1998, Isola et al. 2000, Austin 2002, Paracuellos 2006). These data implement previous research carried out in this Mediterranean wetland (Battisti et al. 2006, Causarano and Battisti 2009, Causarano et al. 2009), confirming the sensitivity of a wide set of water-related species to water changes in different seasons and for different bird species and assemblages.

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