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Water reservoirs dynamics do not affect the abundance and productivity of the bearded tit (*Panurus biarmicus*) in "El Hondo Natural Park" (SE Iberia)

Abstract

Long-term fluctuations of the abundance and productivity of marshland passerines are affected by multiple factors. Water levels fluctuations in man-made wetlands can affect severely the breeding and wintering attempts of highly dependent reed passerines and decrease their abundances simply by dispersal towards better sites. In this work I study if water outputs and inputs in a western Mediterranean coastal semi-arid reservoir "El Hondo Natural Park" do not affect, apparently, the long-term abundances and productivity of the small Spanish endangered population of Bearded Tit *Panurusbiarmicus* ubicated in it. The watershed parameters analyzed during sixteen years (1992-2007) by a Principal Components Analysis (PCA) show that only two main axes, water inputs (PC1) and outputs (PC2) explained most total variance and were the drivers of the water in the reservoirs. None of the bird's dynamics indexes were significantly correlated with the axes, so that water dynamics seem have not taken in to account for the fluctuations of this species, but the flooding of thereservoir with output capacity "Embalse de Poniente" could likely influence the annual productivity of this species, due to the negative but unsignificant correlation with PC2. The maintenance of ponds of enough water quantity and quality (e.g. "La Raja", "Charca Sur") in the "El Hondo Natural Park" during the nesting periods is fundamental for the preservation of this endangered population. The results indicate that further evaluations of the key biotic and abiotic factors who drive this threatened Bearded Tit's population in this isolated and endangered man-made wetland are needed.

Keywords: inland coastal reservoir, water fluctuations, western mediterranean, bearded tit

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Introduction

Long-term fluctuations of the abundance and productivity of marshland passerines can be affected by multiple factors[1–6] and annual water level fluctuations are important abiotic factors affecting them.[7] Similarly, management activities derived of flooding (fisheries; reed management, etc) can affect population fluctuations.[8] In particular, there are some marshland passerines that are highly dependent of fluctuations of water levels on where severe droughts of the water bodies or habitat fragmentation that may infringe severe effects in migration,[9] breeding,[10] dispersal,[11] moult and breeding outcomes.[2,12,13]

However, it has rarely been researched if hydrological fluctuations or reductions of water bodies can affect the abundance of the unusual but endangered highly dependent passerine reedebed specialists.[3,14–16] In the Bearded Tit *Panurusbiarmicus*, in particular, it has been reported that severe floods[16] or the creation of new marshes[17] can infringe high mortality and subsequently downfalls in productivity or to reduce the optimal habitat.[18]

The Bearded Tit is an unusual marshland bird in its European distribution area[19] and the small population in "El Hondo" is likely the only one in Western Europe inside an inland coastal saline reservoir. Spanish populations of this species is nearly threatened.[20,21] For this reason, the study of this population in relation to the watershed dynamics is of particular conservation interest. I examine if watershed dynamics in "El Hondo" reservoirs could affect the long-term abundances and productivity of this small and endangered population by analyzing some water-levels variables and their relationships with population parameters during a sixteen years period (1992-2007). I propose that this isolated population needs supplies of water inputs in some key areas for the nesting, dispersal and feeding.

Study area

Hydrologic system

The hydrology of Southern Alicante (Baix Vinalopo County) is based in a endorheic systemformed in the past centuries by the accumulations of sediments from the Segura river delta that conformed an extense saltmarsh/freshwater marshland in the past.[22] The study area is termed generically as Ramsar Site number 14"El Hondo swamp".[23,24] Is a group of eutrophic lagoons surrounding a man made-construction "El Hondo"built in the beginnings of XX century on the saline and freshwater marshlands. This swamp is declared in 1988 as The "Hondo Natural Park" (38º20'N 00º75'W; Alicante province) due to its international importance for waterbirds. Currently, is immerse in the semiarid fragmented agriculture landscapes of Southeastern Spain and reservoirs are used for irrigation. It contains two main reservoirs flooded with inputs of freshwater water from the Tajo-Segura rivers channels connections of low salinity. Due to the saline soil composition of reservoirs enrichted in calcium carbonate (CO3Ca) termed "white alkali",[25] the water acquires a high saline nature which permits the growth of huge masses of Reed (Phragmites australis). The two reservoirs are termed "Embalse de Levante (hereafter EL)" of 450 Ha of surface and oriented to the East Mediterranean coast and the "Embalse de Poniente (hereafter EP)" of 650 Ha and oriented to the inland West. Water capacity of the reservoirs is 16Hm^3 (22). Water inputs begin in EL and afterwards continue to EP. Other small ponds surround the north and south of these reservoirs (e.g La Raja, hereafter LR) configuring the "El Hondo Natural Park" of 2435 Ha. They are at 2.6 m.a.s.l and distant 15km from the coast.

Methods

The species targeted

The Bearded Tit (*Panurusbiarmicus*) is an ornamented passerine which keeps a sedentary and isolated small population of about 50 pairs in this Park.[26] The population of El Hondo Natural Park is considered to be situated at the southwestern limits of its European distribution range.[27] It was discovered in 1970's decade by[28] and no earlier evidences of its presence in this ecosystem have been obtained in the literature.[29] It is probably a remain of movements of irruptive birds coming from the great emergent population of SE France in the past[14] since wider movements occur in this species.[30] Currently this species faces extinction processes.[21]Another smaller population, not surveyed in this study, is located in the "Santa Pola saltapans Natural Park" (38º19'N00º61'W), a group of saltpans with saltmarshes located to 8 km from southeastern of "El Hondo", in the Mediterranean sea line. No ringing recoveries have been obtained in the area, although an exchange of Bearded Tits among both populations is probable, due to the short distance and presence of reed corridors.[31] The Bearded Tit is surveyed from Constant Effort Sites (CES) since 1992 by the author[32] and is a sedentary bird in the study area with maximum abundances of trapped birds obtained in the beginning of Spring (March-April) and minimum are in the autumn (September-October).[33] In this study, I considered March-October as the breedingperiod and November-February as the winterone according to the annual cycles of the Bearded Tit based in their habitat selection by.[34]

Species monitoring schemes

Bearded Tits (N=238) were trapped with mist-nets and metal ringed in a core area of EL during a sixteen years period (1992-2007, N=16). Since yearly trapping effort was not the same along the study period,[35,36] the annual number of ringed birds was standardized by trapping effort in order to be an estimator of their abundance [(Individuals/ (Hour x m² net x 10000)] (Table 1). Each individual was sexed and aged (adults and juveniles[37]) and the annual productivity was calculated as indicated in Table 1.[38] A complete set of biometric measures was taken but they were not used for this study.

Table 1 Description of hydrological variables recorded in 1992-2007. Water level was measured following a concrete water height meter in each reservoir

Variables	Description
EL	Average annual water level in EL.
EP	Average annual water level in EP.
M	Average of the annual water level in EL and EP.
MS	Average annual water level in summer.
MW	Average annual water level in winter.
LMAX	Annual average of the maximum water level in EL.
LMIN	Annual average of the minimum water level in EL.
LMAXS	Annual average of the maximum water level in EL in summer.
LMAXW	Annual average of the maximum water level in EL in winter.
LMINS	Annual average of the minimum, water level in EL in summer.
LMINW	Annual average of the maximum water level in EL in winter.
LW	Annual average water level in winter in EL.
LS	Annual average water level in summer in EL.
PW	Annual average water level in winter in EP.
PS	Annual average water level in summer in EP.
ABUND	Annual number of total Bearded Tits divided by trapping effort (see text).
PROD	Number of juveniles per adults (see text).
EMT	Sampling effort [(Annual birds / (hour x m^2 net x 1000)]
PRECIPIT	Annual precipitation (mm)

Hydrological data

In the selected study period, I got the variables indicated in the Table 1 and in the Appendix. Hydrological and bird's data variables were previously normalized [log (x)] for posterior analyses because almost 50% of the total variables didn't meet normality according to the Kolmogorov test (P<0.04).

Statistical analyses

All hydrological data was submitted to a Principal Components Analysis (PCA) in order to find the best driversof reservoirs dynamics. Factor scores of the main axes were submitted to Pearson's r correlations (two-tailed) with bird's population data (annual abundances and annual productivity) in order to see the best predictors of the avian population dynamics in this reservoir. Pearson's correlations were not submitted to stepwise Bonferroni's correction because the number of pairwise correlations was N<20.[39] Independent Student' t test were applied to differentiate between means. The IBM-SPSS statistical software v. 23 47 was used in the analysis.

Results

Hydrological characteristics of the ponds

The annual average of the water level in EL was not significantly higher than in EP (Table 2; t18=1.06; p=0.305) and the annual means in winter were slightly not significantly superior than in summer (t_{30}=0.31; p=0.761). Water height in EP in summer was not significantly lower than in winter (t_{30}=0.764; p=0.451) andheight EL was significantly greater in summer than in winter (t_{19}=-2.331; p=0.02). There was a marginally significant trend towards the decreasing of the mean water levels with year during the study period (r_{12}=- 0.569; p=0,053) and the average annual water heights of the reservoirs were independent of the annual precipitation (r_{16}=- 0.335 P=0,288).

Table 2 Characteristics of the water levels in the reservoirs of "El Hondo" Natural Park during 1992-2007. N represents the number of years

Variable	Mean ±SD	N
EL	0,721±0,252	10
EP	0,679±0,339	10
M	0,642±0,311	12
S	0,914±0,224	16
W	0,937±0,203	16
LMAX	0,796±0,261	9
LMIN	0,651±0,275	9
LMAXS	0,784±0,297	9
LMAXW	0,811±0,257	9
LMINS	0,684±0,257	9
LMINW	0,642±0,302	9
LW	0,933±0,281	10
LS	1,141±0,031	11
PW	0,925±0,295	16
PS	0,854±0,225	16
ABUND	15,710±16,630	16
PROD	0,540±1,206	16
PRECIPIT	228,800±74,443	16

Reservoirs dynamics

The results of PCA of fifteen predictor variables of the reservoirs are showed in Table 3. The PCA summarized the variables in two axes (PC1 and PC2) which explained 81,22% of total variance. The first axis, which explained more than 70% of variance (71,99%), is an axis of increases of water in EL, in particular maximum water height in El in winterdetermined by emptying of EP in winter so is an overall axis of water input. The second axis is related to the emptying in EL in winter in favor of flooding in summer in EP, so is interpreted by a water output axis. In general terms, the drivers of the dynamics of water in "El Hondo" are the input of water at EL in winter and output in EP in summer.

Table 3 Results of PCA on hydrological variables summarized in Table 1

Variables	PC1	PC2
EL	0.994	-0.048
EP	0.756	-0.066
M	0.934	-0.067
MS	-0.939	0.19
MW	0.452	0.862
LMAX	0.989	0.011
LMIN	0.990	-0.101
LMAXS	0.908	-0.158
LMAXW	0.938	0.107
LMINS	0.919	0.097
LMINW	0.959	-0.177
LS	0.694	0.376
LW	0.674	-0.221
PS	0.118	0.99
PW	-0.951	0.07
Eigenvalue	10.799	2.053
%Variance	71.992	13.689

Relationships with bird's populations

Factor scores of PC1 and PC2 were not significant related with abundance (PC1 spiltted: r_5=0,642, p=0,243; PC2 vs Log Abundance: r_5=-0,353, p=0,560) and productivity (PC2 splitted: r_4=0,859, p=0,141; PC2 vs Log Prod: r_4=- 0,947, p=0,053).

Discussion

Water levels fluctuations in man-made water-bodies may affect severely the breeding and wintering of waterbirds and decrease their abundances simply by dispersal towards other areas.[6,11,40,41] that could be considered as more appropriate foraging sites.[42] Results here presented are indicative that some Bearded Tit's population parameters are not affected by the dynamics of reservoirs and that the abundances andproductivity are independent of water's inputs and outputs. This could indicate that increases of water levels in some ponds, in particular in EL, could facilitate the dispersal towards other sites as EP with low water levels. This dispersal has a positive in the breeding of this species at this wetland when the levels of EP are good.

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Negative and nearby significant correlations of productivity with index of outputs of water (PC2) could indicate Bearded Tit's need summer water supplies in the ponds with major water capacity that remain dry in summer (EP).[43] In Camargue (SE France) areas with small flooded ground appear to have importance for the breeding of the Bearded Tit.[42] This feature is similar to some areas of EL Hondo where the nesting of Bearded Tit is favoured (ESP, LR), although increases of water in such areas could favor rats predation in nests.[35]

The hydrological dynamics in EL Hondo could be similar to other eastern Mediterranean populations (central Anatolia, Turkey) on where coexist two subpopulations of this species that, in spite of to suffer a isolament degree, they share a gene flow and between them and droughts appear to be a very important, negative factor, facing their extinction.[44,45]

The results of this study are indicative that populations of this species may are suffering an acidification process in the context of global climate change, since a trend in the mean height of reservoirs decrease with years, aspect that should be take into account for further assessment.

Conclusion

This study concludes that the inputs and outputs of water in the reservoirs of El Hondo are independent of population dynamics of Bearded Tit in terms of annual abundance and productivity, so is recommendable to facility inputs of water of high quality in particular at EP,maintaining artificial ponds with islands of reeds with dense cover and enough water quantity and good quality to facility the increase of the nesting sites for this species. Further assessment of what key factors of reservoirs are affecting the populations dynamics of this species are needed.[6]

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Conflicts of interest

The author declares there are no conflicts of interest.

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