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Senescense and dispersal under local climatic variations of bearded reedlings *Panurus biarmicus* at the southwestern limit of their European distributional range

Abstract

Climatic disturbances can determine variations in the body condition and body size in birds on time and hence affect he health status. This study confirms that Bearded reedlings *Panurus biarmicus* express this at small-medium time scales in a age-dependent form at least at semi-isolated local wetlands of Western Mediterranean. To determine body condition and body size, I took biometric measurements during ringing protocols and afterwards I opposed them to climatic variables in 1992-2009. Bearded Reedlings gained condition and lessen size on time as a response to changes of climate at a local scale in the form that wetter and milder local climates influenced negatively the outcome, and this was age dependent. Youngsters improve body condition and adults impair it. Number of adults ringed decreases on time in favour of a stronger condition of the more abundant juveniles. These age variations may reveal that these small populations are becoming senescent, suffering a weakening response that risks its survival. However, dispersal of some age-groups towards suboptimal novel areas could ameliorate this process.

Keywords: reed bird specialist, body traits, climatic outcomes, western mediterranean

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Introduction

Amongst the Eurasian reed-marsh-dwelling passerines, the Bearded Reedling (*Panurus biarmicus, L)* is a remarkably dimorphic bird subject matter of selective forces.[1,2] Its subspecific position and arrangement in Eurasia remained questionable in the old[3,4] and recognized as polytypic species.[5] Since preceding 1960's[6] it spreaded in some European states[7–10] so it was looked upon as a bird of "least conservation" concern.[11] Even, in some countries it has reached a decline (e.g. The Netherlands).[12] In the instance of Spain the species considers directly threatened[13] or endangered[14] and Eastern populations remain actually at risk of quasi-extinction or extinction.[15–17] Concerning the effects of climate change on Bearded Reedling's populations in Europa, the abiotic effects on them in temperate areas reveals drastic downfalls in quantities combined to prolonged floods of reed-beds.[18,19] In northern, cooler places, the growing of temperatures leads to more prolonged breeding seasons enabling more broods[20] but in Western Mediterranean semiarid regions winter minimum temperatures and increments of annual rainfall causes decreasing in mist-netting annual indexes[21] while in Central Mediterranean areas meteorological conditions appear not to be a serious component.[22]

Body condition and body size of birds are inter-connected[23–25] and may rule as a significant proxy of health quality. This is because they signal senescence of populations,[26–28] can be age-dependent,[29–31] readily handled and measured in the field [32,33] and afterwards statistically evaluated.[34] Furthermore, it is proved that body traits to be of major importance to analyze extinction processes n bird's populations[35] and may be influenced by isolation degree. Condition meets with body weight[24,25] and body size relates with measures of external parts of the bird.[36,37]

Earlier studies in Bearded Reedling's regarding body condition and size present sex dependent constraints in size of yearlings during critical physiological demands as the complete moult[38] and sex differences in some traits of juveniles which signal condition .[39] Sex-ratio of broods is not related with body condition in nestlings[40] but colonial females are of considerably higher quality in body condition and size than solitary males.[41]

In this investigation, I try to analyse if some body traits of this species are age-dependent and if they are linked to annual fluctuations along time. I use measures of yearlings (juveniles or adults) collected from standardized ringing protocols[42] in a snall population in "El Hondo Natural Park" considered to be at the southernmost limit of the Western Europa.[43]

On doing so, I try to check the following hypothesis: 1) Bearded Reedlings tend to be persistently heavier and lighter on time 2) this effect is age-dependent: juveniles improve its condition linked to increases of rainfall and temperatures as outcome of climate change, 2) birds of a longer age (adults) impair it in reply to wetter and warmer climates and 3) The two previously hypotheses facilitate a differential dispersal that is age-dependent and enhances ability to some birds to form age groups to cope with novel habitats. Finally, these age discrepancies may reveal senescence by natural selection in this small population, experiencing a probed depressing process, which could put in risk its durability.

Material and methods

The study plateau

The south Alicante-Murcia wetlands complex in South-East Spain corner (Figure1) consists of four internationally protected wetlands: 1) El Hondo Natural Park (2400 Ha; 38º16'N 00º 44'W) is an inland man-made wetland constituted mainly by an inner deep reed-bed belt

and outside a hard salt-marsh zone, 2) Santa Pola's saltpans Natural Park (2570 Ha; 38º12'N 00º37'W) is a structure of saltpans with saline vegetation, 3) La Mata-Torrevieja Natural Park (3743 Ha; 38º 01'N 00º41'W is a littoral saline lagoons complex surrounded by a zone of salt-marshes and 4) Mar-Menor Lagoon Natural Park (13500 Ha; 37º 50'N 37º 34'W) is a hyper saline coastal lagoon encircled by a narrow region of reed-beds and salt-marshes. They are distant among them about 10-50Km. Since the surface of wetlands in Mediterranean has reduced about 50% since the preceding century,[44] the early three groups can be treated as remnants of an enormous marsh swamp existent in southern Alicante in the ancient centuries at the catchments of Segura river basin,[45,46] and where the genetic isolament could be high 88. Only El Hondo Natural Park and Santa Pola's saltpans Natural Park remain with tiny populations of Bearded Reedlings observed on previous 1970's.[47,48] Climatic datasets from the study area (El Hondo Natural Pak) from 1992 to 2009 (N = 18) were collected 11 Km NNE direction: total annual rainfall (248.7±156 21.7mm), mean annual temperatures (19.6 ± 0.3ºC). The annual total ammount of rainfall and annual mean temperatures set up a system of lowlands in Southern Alicante immerse in a semiarid plateau defined by a fragmented landscape with a deficient hydrologic system.[49,50]

Figure 1 Study area plateau at South-Eastern Spain. Oval area corresponds to the south Alicante-Murcia wetland complex covering a surface of about 800km^2 and currently composed by agricultural and urbanized fragmented landscapes with medium-great spots of salt-marshes, reed-beds and open water in the remnants of the a great marshland named "Albufera de Elche" in the past centuries. [46,49,50,88]

The population studied

The small population of the Bearded Reedling studied, established at El Hondo Natural Park was monitored in 160-140 individuals in 1985-2006.[16,45] According current count census (2017) it is expected to be quasi-extinct.[17] Another short distant North Eastern tiny population of[45] individuals in 2005-2006 is detected at the nearby Santa Pola's saltpans and currently considers extinct.[17] Bearded Tits in El Hondo have been systematic trapped for ringing since 1991.[42,51] No birds ringed in any other population have regularly been recovered here but short distant groups are definitely established inside El Hondo[52,53] and observations in transitional fields of both wetlands (Els Carrrisars) have been carried out but Interchange among sites cannot be ruled out from ringnig data.

Biometrics and population data

In order to gather bigger samples sizes and not to differentiate by seasons (summer and winter), I got for first ringed birds (N = 253) in 1992-1995,2002-2007 and 2009 (23±13 individuals per year, N = 11 years). Population was surveyed mainly in summer since 66% (N =167) of them were ringed in March-October) and 44%(N = 88) in November-February so population studied could be mainly breeder because 1) juveniles were the bulk 21 and 2) most adults were in complete moult.[38]

The right wing-length (maximum chord method and to the nearest 0.5mm), bill-length (to the skull and to the nearest 0.1 mm), right tarsus–length (according to the bent method and to the nearest 0.1 mm) were measured.[32] I also recorded the body mass (to the nearest 0.1gr) with Pesola spring balance. Bearded Reedling is a highly dimorphic passerine on which adult males differ in colour from adult females.[5] Juveniles males resembles to juvenile females but can be sexed by bill and iris color.[32,54] Birds were aged as youngsters (juvenile plumage) or older (adult plumage after completing moult) and sexed according.[32] I estimated body condition using the residuals of a regression of body mass on wing length. I used tarsus-length to provide the better estimator of body size instead of other skeletal measures[37] since tarsus-length had a high correlation with wing-length. I determined data from observations of birds at nearby sites by local bibliographic notes.[54,55]

Statistical analyses

For statisitical analysis I used a Generalized Linear Model (GLM).[56] Body indexes were entered in the model as separated dependent variables, age and sex as fixed variables and year and climatic variables (rainfall and temperature) as covariates.[57] All variables were enclosed in the model with all their interactions.[58,59] Climatic variables were chosen because in some Bearded Reedling's populations rainfall and temperatures result a proxy of productivity[18] and breeding outcomes.[20] Spearman correlations were used to verify relations of productivity in the life's tables with year. All statistical nalyses were implemented employing IBM SPSS v23 sofware.[57]

Results

Local rainfall increased significantly by 25.5% (see slope trend formula) in the expanded time scale 1992-2009 (N=18) and temperature increased not significantly in 0.6ºC per year (rainfall= 9.613*Year - 18982.1; F1,16 = 7.285 , P = 0.016; temperature=0.062*Year -104.6; F1,16=1.754 , P=0.204). This local scenario results in wetter and hotter years on time and it is slightly different at the global scenario for the present century at South-East Spain scale, which gives an increase of temperatures and a decreasing of rainfall.[60] Wing-length was substantially related to body mass and explained a 26.5% of variance of the dependent variable (Body mass = 0.219· Wing-length + 0.168; r = 0.515; P < 0.001; d.f = 236). GLM analysis (Table 1) reveals that Bearded Tits lessen body condition but increase body size on time and this is linked to increments of temperatures and rainfall that is age-dependent in the form that juveniles improve condition in contraposition that adults that impair it. Number of adults ringed declined on time (Spearman r = - 0.21; P = 0.861; d.f=15) and the number of juveniles increased (Spearman r = -0.29; P = 0.289; d.f=15) so productivity of juveniles per adult determined an increase along 1992-2006 (Spearman r = 0.33; P = 0.224; d.f=15) all data analyzed from the life-tables of studies in the same site.[61]

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Table 1 GLM Analysis on dependent indexes (condition and size), independent fixed factors (age and sex) and covariates (year, total annual precipitation, mean annual temperature). Significant values (P < 0.05) are in bold

	Condition					SIZE			
Variables	**B**	**X2Wald**	**df**	**P**	**Variables**	**B**	**X2Wald**	**df**	**P**
Intercept	102.989	4.958	1	**0.033**		198.579	6.886	1	**0.019**
Age	-17.53	0.045	1	0.836		-129.117	0.914	1	0.337
Sex	-18.877	0.016	1	0.75		39.509	0.173	1	0.682
Rainfall	0.056	7.224	1	0.055		-0.086	6.18	1	**0.024**
Temperature	0.038	0.685	1	**0.032**		-0.03	0.249	1	0.734
Age*Sex	0.737	0.519	1	0.471		-0.429	0.394	1	0.677
Age*Year	0.029	0.717	1	0.397		-1.036	0.382	1	0.537
Age*Rainfall	-0.015	5.027	1	**0.025**		0.06	1.022	1	0.312
Age*Temp	-0.268	4.932	1	**0.027**		0.039	0.146	1	0.702
Sex*Year	0.017	0.418	1	0.518		0.479	0.111	1	0.739
Sex*Rainfall	-0.06	1.474	1	0.225		-0.017	0.161	1	0.689
Sex*Temp	-0.703	1.402	1	0.236		-0.013	0.032	1	0.859
Age*Sex*Rainfall*Temp		5.575	3	0.134		-0.225	0.065	1	0.799
Deviance	145.782		219			317.562		206	
Akaike (Aic)	592.053					747.747			

Discussion

This research involves a natural selection which is age-dependent and condition-size dependent,[62–65] and that the population of Bearded Reedlings could confront with such variations and to cope with novel habitats, as adaptive process to climate change.[66] This study indicates that condition is really not sensitive to temperature but rainfall operates as a proxy of climatic variations affecting condition.[67,68] Furthermore, the growing temperatures and rainfall influence condition of juveniles negatively and forces to smaller youngsters to make short trips towards outermost novel, more productive areas outside of wetland, considered foraging sites and where changes in morphological traits have been verified[53] as occur in other reed-bed passerines which use suboptimal areas because the diversity of food is higher[19,69] Contrarily, lighter and bigger youngsters after development from nest as chicks contribute to maintain in optimal dense areas inside of wetland making movements of longer distance from nesting and foraging-moulting areas (5-13km, own data of author and[52]). Probably Bearded Tits of younger age are more nomadic in its movements and they are associated to variable peaks of production of reed-seeds of better quality at sparse areas[53] enabling observations towards other distant areas outside of the study area[55,83,85] falling inside the range of Iberian movements[70] but at shorter distances.

Changes in wing shape during complete moult give adults more pointed wings enabling longer faster trips.[42] Greater condition and smaller size of the more abundant youngsters at study area on time[61] is a description that exist morphological adaptions to warmer climates as a skill to cope with an evolving environment, so phenotypic plasticity is favoured.[66] Rainfall is of crucial matter of abundance of birds at Mediterranean ecosystems[71] but affects negatively condition of Bearded Reedlings at South-Eastern Iberian populations. Corresponds to this study, to indicate that in northern cold areas of Europa, Bearded Reedlings benefit of climate warming favouring a protracted breeding seasons and facilitating higher productivity. [20] This local scenario, contradicts with more healthy populations at inland wetlands of Central Iberia where the environmental conditions differ and where productivity and survival is higher.[72] Shrinkage of body size with warmer climates is a universal rule in animals as an ecological response to climate change[73–75] and it is consistent with the findings of this study. On the other hand consider it as a positive effect of phenotypic plasticity which is adaptive,[76] but has exceptions.[77,78] Due to the morphological constraints imposed by the environment at southern latitudes, the system of *Panurus*[80] at semiarid landscapes of South-East Spain it is considered as semi-isolated system where a surplus of individuals change its condition and size[53] and senescence of populations is produced by impoverishment of body traits (see Great Tits *Parus major*).[90]

Conclusions

This investigation concludes that Bearded Reedlings are becoming to be stronger and smaller on time and overwhelmed by increments of some climatic variables examined. In addition, this effect is age-dependent[28] in the form that youngsters improve condition and adults impair it. This adaption could force dispersal of birds towards novel habitats since observations at nearby and semi-distant areas have been reported. Management of cleared and dense reebeds at intermediate areas is fundamental to favour displacements due to the strong requirements of this species for good masses of reed. Further fine studies are need to study these aspects at isolated and decreasing populations across Europe[12,81,82] to implement management and conservation measures of this species to avoid its extinction.[83–90]

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Conflicts of interest

The author declares there is no conflicts of interest.

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