

# Sex-ratio variation in the Bearded Tit *Panurus biarmicus* in El Hondo Natural Park (SE Iberia)

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Adult sex-ratios in birds can be male biased due to higher mortality in females, whereas nestling sex-ratios do not normally differ from equality. I studied the sex-ratios in the Bearded Tit *Panurus biarmicus* by analyzing data from captures with mist-nets in southern Spain over a period of five years. I found that sex-ratios in the population were male-skewed (0.61); juvenile sex-ratios approached equality (0.55), but adult sex-ratios were male-biased (0.67). The observed bias in the adult sex-ratio (57-73%) appears to be greater than the adult avian sex-ratio described in the literature (33-65%). I propose a hypothesis whereby higher-than-normal mortality in adult females due to greater predation could explain such biased sex-ratios. Given that small populations with sex-ratio oscillations may be more prone to extinction, monitoring programs and research to investigate the possible consequences of these fluctuations in patchy populations needs to be carried out.

Key words: Bearded Tit, *Panurus biarmicus*, sex-ratios, El Hondo Natural Park, SE Spain.

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The Bearded Tit *Panurus biarmicus* is a highly dimorphic reed-bed passerine belonging to the *Paradoxornithidae* family of passerines. Three subspecies distributed across Western Palearctic have been described (Robson 2007). *P. b. biarmicus* breeds in Western Europe (Cramp & Perrins 1993) and the populations found in southern Alicante (SE Iberia) are the southernmost in Europe (Gosler & Mogyorósy 1997). The species is neither threatened nor a bird of conservation concern in Europe (Birdlife International 2004). In Spain, however, it was first classified as Near Threatened (NT) at the beginning of the century (López & Monrós 2004) and has been recently revised as Critically Endangered (Peiró *et al.* 2010). The number of Spanish breeding pairs in the period 1998–2002 was low (650–1100) compared to other European countries (France: 3,000–9,000, Italy: 4,000–10,000; BirdLife International 2004); the species has a

patchy distribution in central (Castilla la Mancha: 292–110), northern (Navarra: 87–148) and eastern (Comunidad Valenciana: 172–295) Spain (López & Monrós 2003).

One of the earliest works on this species (Pearson 1975) described the species' complete moult and its eruptive behaviour. Recently, more complete information has been provided by studies of its ornamental traits (Hoi & Hoi 2001a, Romero-Pujante *et al.* 2005, Hoi & Griggio 2008), pair-bond mating system (Hoi *et al.* 1997) and habitat selection (Hoi & Hoi 2001b). Fewer studies have analyzed its sex-ratio in spite of the importance of this parameter for the viability of populations. Donald (2007) showed in fact that threatened bird species may be prone to have unbalanced sex-ratios, which are mostly male-skewed. In the long run, unbalanced sex-ratios may threaten bird populations in habitats affected by serious human disturbance (e.g. irrigation projects).

In some promiscuous palustrine passerines in Europe it has been shown that larger broods tend to be female-biased and smaller broods male-biased, resulting in overall brood sex-ratios that do not deviate from unity (Dyrce *et al.* 2004, Darolová *et al.* 2009). In the Bearded Tit adult sex-ratios are slightly male-biased, but juvenile and fledgling sex-ratios appear to be close to unity (Hoi 1989). Promiscuity and polygamy have been detected (Hoi & Hoi-Leitner 1997) and the species has been shown to be prone to unbalanced brood sex-ratios in favour of females (Darolová *et al.* 2009). However, few studies have ever analyzed the sex ratio in the Bearded Tit's offspring (Bartol & Csörgo 2000), the principal topic of this study.

## Methods

I studied a sedentary population of Bearded Tits in a wetland area of southern Alicante (SE Iberia). The most important area for the species is El Hondo Natural Park (38°16'N 00°41'W), which is located about 11 km inland from the Mediterranean coast. El Hondo is a 2,500 ha man-made wetland in which the common reed *Phragmites australis* is the dominant emergent plant. The Bearded Tit population at El Hondo was estimated at 140 individuals in 1985 (Navarro 1988), 100 in 1998–2000 (López & Monrós 2003) and 140–160 in 2005–2006 (López *et al.* 2007). Bearded Tits in El Hondo have been systematically trapped for ringing since 1991 (Peiró 1997); no birds ringed in any other population has ever been recaptured here (Peiró & Maciá 2002, Frías *et al.* 2007), although immigration from nearby breeding sites cannot be ruled out (e.g. Santa Pola saltpans).

Birds were trapped between 1991–2006 using a variable number of four-panel mist-nets (30–202 m in length, 2.5 m high, 27 mm mesh size), which were set in three different groups for variable periods of time from sunrise to sunset (mean effort:  $12,862.38 \pm 3,105.86$  hours  $\times$  m<sup>2</sup> net,  $n = 16$  years) in three reed-bed plots in the core area of the Natural Park (Table 1). Due to the small number of birds ringed in some years, I only analyzed data from those years with  $n \geq 20$  birds ringed (1992–1993, 2002–2003 and 2005; Table 1); most birds were trapped in the summer (May–August: 59%;  $n = 167$ ). The mesh size used

was appropriate for capturing birds of the size of the Bearded Tit that weigh less than 16 g (see results; Pardieck & Waide 1992). Body condition was estimated using the residuals of a regression of wing length, dependent on body weight (weight =  $0.219 \cdot \text{wing-length} + 0.237$ ;  $F_{1,156} = 66.828$ ;  $P = 0.000$ ;  $R^2 = 0.549$ ) and the differences between sexes within ages were calculated by means of the non-parametric Mann Whitney U-Test.

Juvenile or young birds before or during complete post-juvenile moult were differentiated from adults by plumage features (Svensson 1992) and iris colour (Wilson & Hartley 2007). After the complete post-breeding moult, which is undertaken by both juveniles and adults, first-year birds cannot be discriminated morphologically from adults, and all were grouped together in the same category. Sexes were distinguished by bill coloration once they had left the nest (Darolová *et al.* 2008). I considered the juvenile sex-ratio to be the ratio of juvenile males vs. the total number of juveniles. Alternatively, the adult sex-ratio was calculated as the ratio of all adult males vs. the total number of adults (birds that had completed the post-juvenile moult). Sex-ratio at population level was calculated as the proportion of males vs. total birds in all study years (Table 1). I used a set of 22 recaptures from 1991–2006 to assess differences in retrapping rates (birds retrapped/total ringed  $\times 100$ ) between ages and sexes. Chi-squared contingency tests were used to detect whether or not sex-ratios are skewed. I used Chi-squared tests instead of the G-Test, since in the total samples the absolute difference between observed and expected values was less than expected (Sokal & Rohlf 1981). All tests were two-tailed. Statistical analyses were conducted with SPSS v.11 and PAST v. 1.60 packages; means are given  $\pm$  SE.

## Results

The total number of birds trapped was not influenced by the netting effort during the annual time series (Pearson's correlation;  $r_5 = 0.029$ ;  $p = 0.963$ ). Considering only data from 1992, 1993, 2002, 2003 and 2005, more males were caught (sex-ratio: 104 males: 63 females), giving an overall male-skewed sex-ratio (0.62) that does not meet equality ( $X^2_1 = 4.61$ ;  $p = 0.0318$ ; Table 1). Juvenile numbers were not significantly male-biased (34:28), and had a sex-ratio of 0.55

**Table 1.** Numbers of each age and sex class of Bearded Tits ringed in El Hondo from 1991-2006. Netting effort: [Hours x m<sup>2</sup> net]. See text for explanations.  
*Nombre de mallerengues de bigotis anellades al Fondo durant el període 1991-2006. Esforç de trampeig: [hores x m<sup>2</sup> xarxa].*

Year					Juvenile		Adult		Sex-ratio			Netting Effort	
	Adults	Juveniles	Males	Females	Totals	Males	Females	Males	Females	Juveniles	Adults		
1991	1	1	2	0	2	1	0	1	0	1,00	1,00	1,00	4738
1992	32	9	27	14	41	4	5	23	9	0,66	0,44	0,72	40845
1993	28	0	16	12	28	0	0	16	12	0,57	0,00	0,57	39825
1994	13	1	7	7	14	0	1	7	6	0,50	0,00	0,54	22622
1995	10	0	3	7	10	0	0	3	7	0,30	0,00	0,30	12902
1996	3	0	2	1	3	0	0	2	1	0,67	0,00	0,67	10933
1997	3	0	1	2	3	0	0	1	2	0,33	0,00	0,33	9875
1998	0	0	0	0	0	0	0	0	0	0,00	0,00	0,00	4993
1999	0	1	0	1	1	0	1	0	0	0,00	0,00	0,00	248
2000	1	1	2	0	2	1	0	1	0	1,00	1,00	1,00	383
2001	0	0	0	0	0	0	0	0	0	0,00	0,00	0,00	382
2002	7	34	26	15	41	21	13	5	2	0,63	0,62	0,71	10112
2003	26	7	24	9	33	5	2	19	7	0,73	0,71	0,73	16128
2004	9	7	11	5	16	5	2	6	3	0,69	0,71	0,67	4860
2005	12	12	11	13	24	4	8	7	5	0,46	0,33	0,58	16273
2006	11	0	8	3	11	0	0	8	3	0,73	0,00	0,73	10679

that meets equality ( $X^2_1 = 0.13$ ;  $p = 0.72$ ). Juvenile males were not significantly in better body condition than juvenile females (juvenile males:  $0.173 \pm 0.20$ ; juvenile females:  $-0.288 \pm 0.11$ ; U-Mann Whitney test:  $U = 297$ ;  $p = 0.150$ ;  $df = 56$ ). By contrast, the adult sex-ratio (0.67) was significantly skewed toward males (70:35;  $X^2_1 = 5.36$   $p = 0.021$ ), which did not have better body condition than females (adult males:  $0.042 \pm 0.09$ ; adult females:  $-0.042 \pm 0.15$ ;  $U = 1017$ ;  $p = 0.381$ ;  $df = 101$ ). Mean annual sex-ratios were male-skewed ( $0.61 \pm 0.05$ ) and were not influenced by the trapping effort (in juveniles:  $r_5 = -0.65$ ;  $p = 0.229$ ; in adults:  $r_5 = -0.248$ ;  $p = 0.687$ ). Recapture rates of males and females (11.4%;  $n = 140$  and 6.8%;  $n = 89$ , respectively) were equally likely ( $X^2_1 = 0.63$ ;  $p = 0.427$ ), although the retrapping rate in juveniles was extremely low (1.5% of 73 birds).

## Discussion

This study found that overall sex-ratios are male-biased in the mist-netted population of Bearded

Tits in El Hondo, and varied annually by 46–73% during the five study years in which most of the data were obtained. Males outnumbered females in a slightly greater proportion than in the avian sex-ratios described in literature (33–65%, Donald 2007). Sex-ratio biases were slightly higher in this study area ( $0.61 \pm 0.05$ ) than in the population in the Camargue (SE France) (0.57) and Venice (NE Italy) (0.57); data from these latter populations were obtained using the same methodology (i.e. mist nets; Brocchieri *et al.* 1992). Although juvenile sex-ratios appear to be close to unity, adult sex-ratios are skewed towards males in El Hondo. In the Camargue and Venice both juvenile and adult sex-ratios were close to unity (0.55–0.59) (Brocchieri *et al.* 1992). In the Ebro valley (NW Iberia) data were similar to those from El Hondo (0.69): juvenile sex-ratios (0.75) were skewed toward males and adult sex-ratios were nearly identical to those from El Hondo (0.66) (Albaiceta & Sanz 2007). A possible cause of this skew in the adult sex-ratio is higher mortality in adult females than in adult males, which cannot be attributed to poorer body condition. In adults,

females may suffer more predation because they spend more time close to the nest. Despite the fact that low sample sizes prevented any statistical comparisons, few juveniles were recaptured in the study area, suggesting that they may disperse more than adults and/or suffer higher mortality rates. Darolová *et al.* (2009) found that the sex-ratio was strongly skewed in Bearded Tits broods and that significantly more broods than expected contained just a single sex, above all of females. Darolová *et al.* (2008) found that female nestlings were heavier than males, possibly as a result of greater maternal allocation. Pair bonds between juveniles have been observed in this species (Amato *et al.* 1989, Bibby 1983, Cramp & Perrins 1993). However, I failed to find any juveniles in El Hondo with brood-patches and so the adult sex-ratio I measured can be considered to truly represent the sex-ratio of the reproductively active portion of the population.

To preserve healthy Bearded Tit populations, female and juvenile survival rates should be increased (Wilson 2005) by improving the quality of reed seeds (Burguess & Evans 1989). Demographic data (e.g. dispersal, survival and recruitment) obtained for all age classes and sexes (Lande *et al.* 2006) are essential if we are to understand population dynamics and predict population viability (Gerber 2006). Further studies in other populations including constant-effort mist-netting are needed to investigate how sex-ratios fluctuate and the possible consequences at population level.

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## Resum

### Variació en el quocient sexual de la Mallerenga de bigotis *Panurus biarmicus* en el Parc Natural del Fondo (SE Iberia)

El quocient sexual dels ocells adults pot estar esbiaixat a causa d'una major mortalitat en les femelles, mentre

que en les llocades aquesta relació no sol diferir de la igualtat. Es va estudiar el quocient sexual en la Mallerenga de bigotis *Panurus biarmicus* mitjançant l'anàlisi de les dades de captura amb xarxes japoneses al sud d'Espanya durant un període de cinc anys. Es va trobar un quocient sexual poblacional a favor dels mascles (0,61); un quocient sexual juvenil proper a la igualtat (0,55), però el quocient sexual dels adults estava esbiaixat cap als mascles (0,67). El biaix observat en el quocient sexual dels adults (57–73%) sembla ser més gran del que s'ha descrit a la bibliografia (33–65%). Es proposa una hipòtesi segons la qual hi hauria una mortalitat més alta del normal en les femelles adultes a causa d'una major depredació i això podria explicar aquest biaix. Atès que les petites poblacions amb oscil·lacions en el quocient sexual són més propenses a l'extinció, són necessaris programes de seguiment i estudis encaminats a investigar les possibles conseqüències d'aquestes fluctuacions en les espècies amb poblacions de distribució molt localitzada.

## Resumen

### Variación en la razón de sexos del Bigotudo *Panurus biarmicus* en el Parque Natural del Hondo (SE Iberia)

La razón de sexos de los pájaros adultos puede estar sesgada debido a una mayor mortalidad en las hembras, mientras que en las nidadas esta relación no suele diferir de la igualdad. Se estudió la razón de sexos en el Bigotudo *Panurus biarmicus* mediante el análisis de los datos de captura con redes japonesas en el sur de España durante un periodo de cinco años. Se encontró una razón de sexos poblacional a favor de los machos (0,61); la razón de sexos juvenil cercano a la igualdad (0,55), pero la razón de sexos para adultos estaba sesgada hacia los machos (0,67). El sesgo observado en la razón de sexos para los adultos (57–73%) parece ser mayor de lo descrito en la bibliografía (33–65%). Se propone una hipótesis según la cual habría una mortalidad más alta de lo normal en las hembras adultas a causa de una mayor depredación y esto podría explicar este sesgo. Dado que las pequeñas poblaciones con oscilaciones en la razón de sexos son más propensas a la extinción, son necesarios programas de seguimiento y más estudios encaminados a investigar las posibles consecuencias de estas fluctuaciones en las especies con poblaciones de distribución muy localizada.

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