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Sexing, ageing and moult of Buzzards *Buteo buteo* in a southern European area

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In order to obtain a reliable method for sexing and ageing Buzzards *Buteo buteo* breeding in southern Europe, 115 birds from a wildlife rehabilitation centre and 43 trapped birds were measured, sexed and aged over four years (2000-2003). Dead birds were sexed by examining their gonads, and live birds by the presence of a brood patch. Wing length, minimum tarsus width and body weight were the only variables which differed significantly between the sexes, although there was much overlap for the wing length and weight. Buzzards with less than 7 mm minimum tarsus width were male and those greater than 7.9 mm were female. Birds did not complete moult in one year, moulting less than 60% of the flight feathers in one season. The first and the second moult followed a pattern, but afterwards moult was unpredictable and totally asymmetric. Also, half the females and 33% of males had started to moult within 30 days of their chicks hatching. These results differ from those published for Buzzards from northern Europe. The size and moult pattern depend on factors such as prey availability and migratory status, which in turn vary between areas. We therefore suggest caution when considering the moult strategies, ageing criteria and sexing criteria published for other countries.

The ability to identify correctly the age and sex of birds has important implications for conservation research (eg Zuberogoitia *et al* 2002, Ferrer & Besson 2003, Penteriani *et al* 2003). For instance, Krüger & Lindström (2001) were not able to age the adult birds, in their study of Buzzards *Buteo buteo*, and wrongly assumed that they start breeding in their third calendar year (Walls & Kenward 2001). This problem becomes more acute when considering that, in Europe, most work has been conducted in northern regions and might not apply to raptor populations around the Mediterranean. For example, it has been shown that the moult pattern of owls differs between northern and southern European countries (Martinez *et al* 2002). As a direct consequence, there is scarce, and probably even biased, knowledge of the age and sex structure of bird populations in Mediterranean areas in old databases.

Buzzards are mostly sexed or aged following the criteria found in Baker (1993) and Forsman (1999). They distinguish three age classes; juvenile (first winter, EURING code 3 or 5), subadults (second winter, code 5 or 7) and adults (third winter or older, code 6 or 8), but they did not establish the moult pattern in depth and provide rather few notes on sexing. Juvenile birds usually stay in the parental territory during their first year (Walls & Kenward 2001), although other authors have described groups of juveniles that do not hold territories and sometimes roost close to one another (Hohmann 1994). Afterwards, birds become territorial as they age, and aggressively defend their territory (Walls & Kenward 2001). Such aggressive displays can be related to the age of individuals, their breeding status, or both (Walls & Kenward 2001). Moreover, major differences in reproductive performance are commonly associated with age, sex, body size and other phenotypic characteristics (Krüger & Lindström 2001, Krüger *et al* 2001a, 2001b, Roulin *et al* 2001, 2003). However, few works have tried to test for relationships between these traits and moult, in spite of the fact that moult is a process demanding high amounts of energy (Hirons *et al* 1984, Petty 1994).

In this paper, we describe how to sex and age Buzzards in a southern European population and test for possible relationships between moult patterns and age and sex.

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METHODS

The study was conducted in a 40 km^2 area near Bilbao, Spain. Data were obtained from Buzzards brought to the wildlife rehabilitation centre of Biscay (n = 115) and from birds trapped in the wild (n = 43). First, those birds injured (mainly shot) that entered the rehabilitation centre and subsequently died were analysed and measured between 2000 and 2003. For these birds, body weights were not considered because they were not generally representative of normal conditions. Only recently dead birds, with fresh body structures, were used. We did not consider frozen samples due to the *post mortem* reduction in size of the tissues. We sexed individuals by internal examination of the gonads. These birds were used to establish the sex criteria and to determine the moult pattern. For the study of the moult only, we also considered those birds that were trapped in good health (eg birds captured in a barn trying to hunt chickens) and which were immediately released after entering the rehabilitation centre.

Second, we trapped adult birds using a mist net and a live Eagle Owl *Bubo bubo* between 2000 and 2003 (under special licence of the Administration, Diputación Foral de Bizkaia). Nets were placed close to the nests of known pairs that had been monitored since 1996 within our research area. These birds were sexed by examining the brood patch, which is only well developed in females.

We recorded wear, colour, age pattern and growth of the flight-feathers (remiges and rectrices) for every individual; for each wing, this gave us data for 10 primaries, 13 secondaries (Buzzards have 14 secondaries but the innermost are usually difficult to find), and 12 rectrices. Primaries were numbered descendantly, (from inside to outside), secondaries were numbered ascendantly (from outside to inside), and rectrices were number centrifugally (from the centre outwards).

Juvenile feathers differ from those of adults mainly in the subterminal band of the rectrices (Baker 1993, Forsman 1999) and remiges. The subterminal band in the tail of juveniles is, on average, narrower than in adults, being quite similar in width to the nearest bands. Additionally, the subterminal band of remiges is narrower in juveniles; this is noticeable mainly in the secondaries, which are also narrower and of a more pointed appearance (Baker 1993). This difference is more evident when there are two different generations of remiges, one of them juvenile.

In juveniles all the flight-feathers have the same wear pattern and show the juvenile subterminal band. Second winter birds (EURING age code 5 or 7) retain some juvenile feathers, which are paler and show a great degree of wear relative to the newer, adult feathers. Adult birds have two or three different generations of adult feathers (Table 1).

Statistic analyses

Biometrics were analysed using bivariate analyses (Mann-Whitney U-tests) and multivariate analyses (Discriminant Analyses with forward step methods) in order to obtain dimorphic variables (Morrison *et al* 1998). Moreover, we applied Cohen's Kappa, a simply derived statistic that measures the proportion of all possible cases that are predicted correctly by a model after accounting for chance (Manel *et al* 2001).

RESULTS

Sexing

Wing length, minimum tarsus width and body weight were the only measured variables which significantly differed between the sexes (Table 2). The was much overlap between the sexes for wing and body weight, but minimum tarsus width was more diagnostic; those birds with less than 7 mm minimum tarsus width were male and those with more than 7.9 mm were female. We used discriminant analyses to identify the best predictors of sex. The standard coefficients were; wing 0.121, minimum tarsus-width 0.813, and body weight 0.410 (Cannonical correlation = 0.862; $\chi^2 = 63.035$; $P < 0.001$). The analyses correctly classify 94.0% of the cases (K = 0.880, SE = 0.067, $t = 6.225$, $P < 0.001$).

The first moult

There was no evidence of moult in any of the 36 first calendar year Buzzards analysed between the fledgling season and the end of the year. Buzzards start moulting in their second calendar year, normally at the end of May or in June. There were minor exceptions related to individuals having lost some feathers through accidents. Seventeen birds analysed between January and April had all juvenile feathers, but two had started

Table 1. Summary key for ageing Buzzards by plumage state. Cy = calendar year, EURING code in brackets.

Autumn	Spring	Remiges and rectrices
1st cy (3)	2nd cy (5)	Juvenile pattern
2nd cy (5)	3rd cy (7)	Juvenile and one adult generation
3rd cy (7)	4th cy (9)	Two adult generations and some juvenile retained
3th cy+ (6)	4th cy+ (8)	All adults, two generations
5th cy+(10)		All adults, three generations

Table 2. Biometrics of Buzzards in relation to sex. The sexes are compared with Mann Whitney U tests.

	Sex	N	Mean ± SD	Range	95% CL for the range	U	*P*
Wing (mm)	♂	56	382 ±27.1	226 -417	328 -436	606.5	<0.001
	♀	53	400 ±15.7	336 -423	369 -431		
Tarsus (maximum length) (mm)	♂	32	82 ± 3.9	70 - 88	74 - 90	368	0.453
	♀	26	83 ± 2.7	77 - 87	77 - 79		
Tarsus (notch to scale) (mm)	♂	8	75 ± 3.8	70 - 79	66 - 84	39	0.521
	♀	12	73 ± 2.4	68 - 77	68 - 78		
Minimum tarsus-width (mm)	♂	58	6.9 ± 0.4	5.7 - 7.9	6.0 - 7.7	606.5	<0.001
	♀	49	7.7 ± 0.5	7.0 - 8.8	6.7 - 8.7		
Tail length (mm)	♂	32	222 ±12.2	200 -243	197 -247	280.5	0.034
	♀	26	229 ±10.1	210 -248	208 -250		
Body weight (g)	♂	23	662 ±72.6	500 -800	512 -812	56.5	<0.001
	♀	30	800 ±66.8	600 -880	663 -936		

moulting some of them. On 30 January 2000 a male had changed secondaries 5, 6 and 7 of the right wing and secondaries 1, 2 and 3 of the left, and on 18 February 2001 a female had rectrice 2 growing on the right. All 19 birds analysed after June had new feathers.

The moult continues until November, with four second calendar year Buzzards captured in September and October showing active moult. We also trapped a bird on 7 November 2000 finishing its moult, with rectrice 2 still growing on the right side. Neither of the two individuals analysed in December showed any signs of moult.

The first moult is usually symmetrical in the primaries. Buzzards always replace feathers from primary 1 to primary 6 or 7. Moult starts with primary 1 and when this feather is growing, moult continues with primary 2, and so on until primary 6 or 7. It is very rare for this pattern not to be found, although it is possible to find birds that have retained some intermediate primaries.

The moult of the secondaries is usually asymmetric, starts on secondary 1, 2 or 5 and continues in different moult loci. The number of moulted secondaries varies between 5 and 23 (Table 3). On average less than 50% of the secondaries are moulted, although some well-fed birds can moult almost all of them.

The rectrices are moulted asymmetrically. The moult usually starts with a central feather, beginning when the bird drops its 3rd or 4th primary. Although there are too many variations to establish a pattern, the outermost rectrices are almost always changed in both sides. The number of tail feathers moulted varies a lot, possibly depending on the body condition of the bird, but it is very rare to find all the tail completely moulted (Table 4).

The second moult

The second moult commences in the first half of May (Table 5). None of seven Buzzards analysed between January and April had started their moult. The last third calendar year bird analysed was on 8 October 2002, when it showed an active moult that involved one primary, one secondary and three tail feathers. The second moult starts with the first or second primary, replaced one year before, and continues with the retained, juvenile feathers. The first juvenile feather moulted is the next to the last moulted in the first moult, second calendar year (Table 5). The sequence of the second moult depends on those feathers moulted one year earlier. One bird shot in October was still moulting, and had replaced nine primaries (45% of primaries) and six tail feathers (50% of tail).

Moult in adults

Most of the adult Buzzards involved in this study were breeding birds. There were no moulting individuals recorded between January and April (n = 11), although one male had the 4th right rectrice growing on 19 January 2000. During the first half of May we trapped one male without any sign of moult. On 17 May we trapped a moulting female with 2nd left rectrice growing

Table 3. Percentage of new feathers found on Buzzards after the first moult. We considered only those birds that had completed moult, ie those examined between November and May.

Feathers	% moulted (mean ± SD)	Number range	N
Primaries	64 ± 11.0	8 – 17	12
Secondaries	46 ± 20.0	5 – 23	11
Rectrices	74 ± 24.7	4 – 12	12

Table 4. Percentage of feathers changed after the first moult for Buzzards. P = Primary, S = Secondary, R = Rectrice. N = number of birds sampled.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10				N
Right	100	100	90.9	90.9	90.9	100	36.4	0	0	0				11
Left	100	100	100	100	100	77.8	44.4	0	0	0				9
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S23	
Right	100	60	10	10	90	70	40	20	30	10	30	30	10	10
Left	62.5	62.5	50	37.5	100	62.5	50	25	25	37.5	37.5	12.5	12.5	8
	R1	R2	R3	R4	R5	R6								
Right	63.6	72.7	54.5	81.8	72.7	100								11
Left	81.8	81.8	72.7	72.7	72.7	90.9								11

Table 5. Sequence of moult starting in the third calendar-year for three Buzzards. N = new feather recently moulted, G = growing feather.

		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10			
Right	19 May	G						G						
	31 May	G							G					
	16 June	N						G						
Left	19 May	G												
	31 May		N					G						
	16 June		N					G						
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S23
Right	19 May			G										
	31 May				G									
	16 June		G				N					N		
Left	19 May			G										
	31 May			G										
	16 June	N				N								G
		R1	R2	R3	R4	R5	R6							
Right	19 May													
	31 May													
	16 June		N		N	G								
Left	19 May													
	31 May													
	16 June	G												

Table 6. Percentages of age differences of feathers between the right and left wings of Buzzards.

	% (mean ± SD)	% range	Number with full symmetry	N
Primaries	24 ± 16.0	0 - 60.0	5	46
Secondaries	27 ± 16.1	0 - 61.5	5	46
Rectrices	16 ± 16.8	0 - 66.7	17	46

Table 7. Percentage of new feathers in adult Buzzards. We considered only those birds that had completed moult, ie those examined between November and May.

Feathers	% moulted (mean ± SD)	Number range	N
Primaries	64±11.6	8 - 17	21
Secondaries	49±14.2	7 - 21	16
Rectrices	88±14.2	6 - 12	20

and secondary 1 on the right replaced. Nevertheless, 63% of males (n = 8) and 71% of females (n = 7) had not started moulting in the second half of May. Likewise, 42% of males (n = 12) and 33% of females (n = 9) had not started moulting in the first half of June. Afterwards, all birds trapped (n = 7) were moulting

The duration of the moult period is variable, extending to the end of October. Moulting adult birds were trapped on 27 October and on 2 November. No adult bird was detected moulting after this date (n = 12).

The moult sequence of Buzzards is asymmetric (Table 6). There were only five birds with the same pattern in the primaries and another five with the same pattern in the secondaries. The moult of tail feathers was symmetrical in 17 out of 43 birds. This is mainly due to the fact that several birds changed all the rectrices in one season.

We found no evidence of complete moult in Buzzards, neither as juveniles nor as adults, and there was no statistical difference between juveniles and adults in the proportion of feathers moulted (Mann-Whitney U-tests; primaries U = 113, P = 0.645; secondaries U = 72, P = 0.451; rectrices U = 84, P = 0.170).

Eight out of 20 adults had completely new tails and three had retained only one feather. Six or seven primaries were replaced in each wing, with one bird each having replaced eight and nine feathers in each wing. The moult of the secondaries was less extensive (Table 7). Moult usually began in the primaries. The mean number of primaries moulted during the first month (June) was 4.0 (SD = 3.16, n = 13), the mean for secondaries was 2.3 (SD = 2.21, n = 13) and rectrices the mean was 1.3 (SD = 2.01, n = 13). Half of the breeding females (n = 10) started to moult within the first 30 days of their chicks hatching. After this age, all the females trapped were moulting (n = 4). Only 33% of males (n = 9) had started to moult within the first 30 days of the chick period, and we trapped two males, which had 40 day old chicks, that had not started to moult.

DISCUSSION

Walls and Kenward (1995) sexed Buzzards by measuring the minimum tarsus width at fledging: birds with tarsi less than 6 mm were classified as males, with a possible 5% being classed incorrectly. They used this criterion in several research projects involving Buzzards (Kenward & Walls 2000, Walls & Kenward 2001), but it would be misleading to apply it to our study population because almost all the males analysed had tarsus widths greater than 6 mm. Moreover, we measured the minimum tarsus width of 46 nestlings and only one of them, at 15 days old, had a tarsus width less than 6 mm (own unpublished data). Our results show that in our study area, birds with a minimum tarsus width less than 7 mm are most likely to be male. This criterion is likely to be less reliable during winter, when territorial birds share the area with wintering, larger and heavier individuals arriving from Scandinavia (Cramp 1985).

Wing length and body weight are the other two variables which are useful to sex birds in our study area. Despite considerable overlap, we can still correctly sex 94% of the birds if we use the three variables together.

Buzzards do not undergo a complete moult of their flight feathers in one season, neither as juveniles nor as adults. The moult is asymmetric, mainly in secondaries and rectrices. The moult sequence is only predictable in the post-juvenile and second moults. Our results differ from those reported by Cramp (1985), Baker (1993) and Forsman (1999) who found that Buzzards complete the moult annually, but that some remiges frequently remain unmoulted, most often in the first moult. The reported moult periods also differ. Our birds started mainly in June, when the chicks were two or three weeks old, and finished in November. Cramp (1985) limits the moult season to between April-May and September-November, with females starting during incubation, but males usually several weeks later. We also found that breeding males started moulting later than their female partners and suggest the delay is a result of differences in parental care behaviour. Males may delay moult because of the constraints of hunting to provision nestlings, whereas females are mostly incubating or brooding during the early chick stages.

In conclusion, the moult strategies of Buzzards seem to differ between regions within Europe, and are likely to depend on factors such as prey availability and migratory status. We suggest caution when extrapolating moult strategies and ageing and sexing criteria published for other countries, and even for other areas within countries, when prey availability or other conditions differ.

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