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Biometrics of the Southern Grey Shrike *Lanius meridionalis* in relation to age and sex

FRANCISCO GUTIÉRREZ-CORCHERO[1], FRANCISCO CAMPOS[2], M. ÁNGELES HERNÁNDEZ[1]* and ANA AMEZCUA[1]
[1]*Department of Zoology & Ecology, Faculty of Sciences, University of Navarre, E-31080 Pamplona, Spain* [2]*European University Miguel de Cervantes, c/ Padre Julio Chevalier 2, E-47012 Valladolid, Spain*

The biometrics of Southern Grey Shrike *Lanius meridionalis* and differences from the closely related Great Grey Shrike *L. excubitor* are poorly characterised. The aim of this study was to describe sex and age variation in external biometric measurements for the nominate Southern Grey Shrike *L. m. meridionalis* in a population from northern Spain. In total, 174 Southern Grey Shrikes were ringed, measured, and sexed by molecular techniques. The overall biometry of the shrikes was summarised by Principal Components Analysis (PCA). There were significant differences in size between sex and age classes. We observed a sexual dimorphism in size, with adult males the largest and yearling females the smallest. According to the PCA, only the first principal component showed significant sex and age differences, and these were related to the tail, wing, third primary, white on primaries and white on rectrices. According to these data, and at least in terms of biometry, the Southern Grey Shrike is more similar to the Loggerhead Shrike *L. ludovicianus* than to the Great Grey Shrike.

The Southern Grey Shrike *Lanius meridionalis* is a socially monogamous passerine without obvious sexual dimorphism in plumage. Ten subspecies have been described, with a largely Afro–Asian distribution, and the nominate *L. m. meridionalis* is mostly found in the Iberian Peninsula and southeastern France (Lefranc & Worfolk 1997, Harris & Franklin 2000). In the Iberian Peninsula it is sedentary (Hernández 1999). According to Isenmann & Bouchet (1993), the Southern Grey Shrike is a different species from the Great Grey Shrike, and this has been accepted by taxonomic authorities (British Ornithologists' Union 1997). Both species are part of a superspecies *Lanius [excubitor]* that includes the Chinese Great Grey Shrike *L. sphenocercus* and the Loggerhead Shrike *L. ludovicianus* in North America (Panov 1995, Schön 1998). The taxonomic separation between the Southern Grey Shrike and Great Grey Shrike is based on morphological, ecological and behavioural differences (Isenmann & Bouchet 1993, Panov 1995, Schön 1998). More recently, genetic differences have also been described (Hernández *et al* 2004).

Nonetheless, little is known about the biometrics of the Southern Grey Shrike. The only information available is based on measurements of a few museum specimens (Cramp & Perrins 1993) and, more recently, on a study of live animals from the central-west Iberian Peninsula (Infante & Peris 2004). The goal of this study was to provide a detailed description of the biometrics of the nominate Southern Grey Shrike in relation to sex and age of live animals, and to compare the results with other populations and closely related species.

* Correspondence author
Email: mahermin@unav.es

METHODS

Study site and capture methods

We captured 174 shrikes during January–December (1999–2002) in the province of Navarre (northern Spain). Birds were captured using a variation of the Potter trap (Craig 1997), ringed, measured and sexed.

Biometrics and age determination

The following body measurements were taken according to Svensson (1992): the length of the wing (maximum chord), third primary (3P) and tail feathers were measured with a 0.5 mm precision ruler; the length of the tarsus, middle toe and bill height, width and length (from the tip to the distal edge of nostrils) were measured with a 0.1 mm precision calliper. We also measured the extent of white on the primaries (WP, from distal edge of basal white area to wrist) and on the rectrices (WR, greatest length of white spot on inner web of the distal end of outer rectrix) (Fig 1) with a 0.5 mm precision ruler as described by Collister & Wicklum (1996). In each shrike, both WP and WR were

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measured three times and the final value used for analysis was the average of these three measurements. Finally, birds were weighed using a 0.1 g precision balance. Not all measurements were taken on all birds and, therefore, the sample size varied. Weight was not considered in the analysis since it can vary substantially during the breeding period (Collister & Wicklum 1996, Takagi 1996), but the average value is reported.

The birds were classified as yearlings or adults. The yearlings (Euring age codes 3 or 5) had undergone a partial moult in summer and winter (Svensson 1992) resulting in a significant colour contrast in the wing feathers: newly moulted, shiny-black greater, median and lesser coverts contrasting with unmoulted black-brownish primaries, secondaries and primary coverts (retained juvenile feathers). The adults were two or more years old (Euring

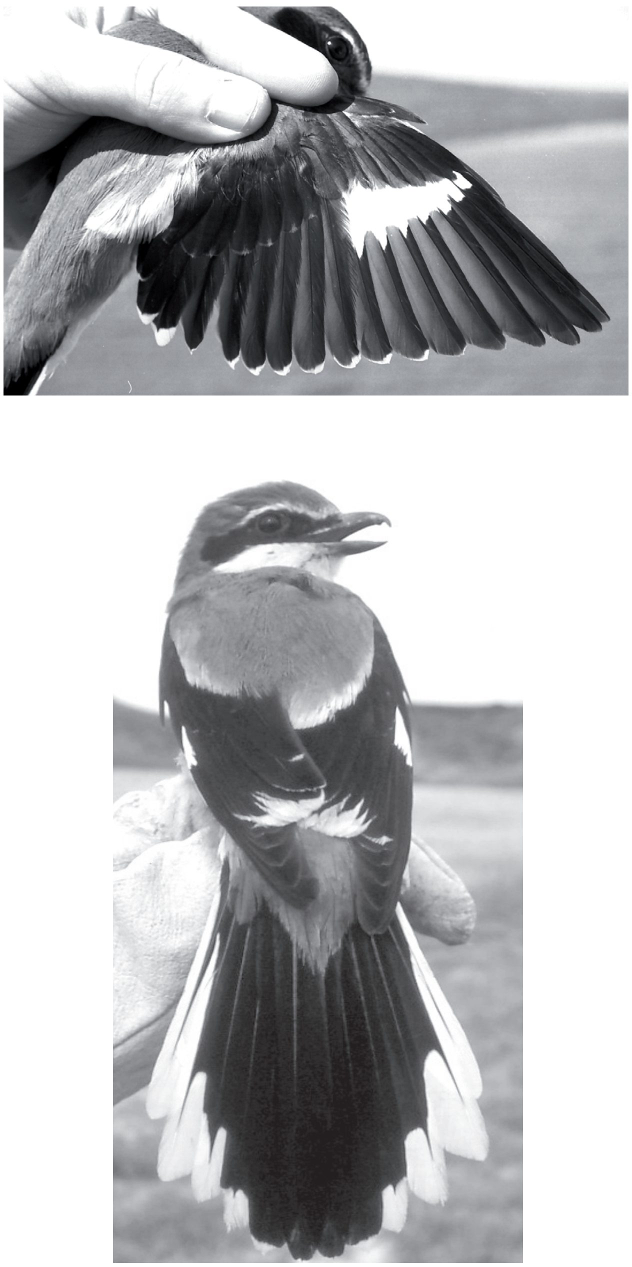

Figure 1. Pattern of wings and tail in the Southern Grey Shrike, showing the white wing patch at the base of the primaries and the white at the end of the outer rectrices.

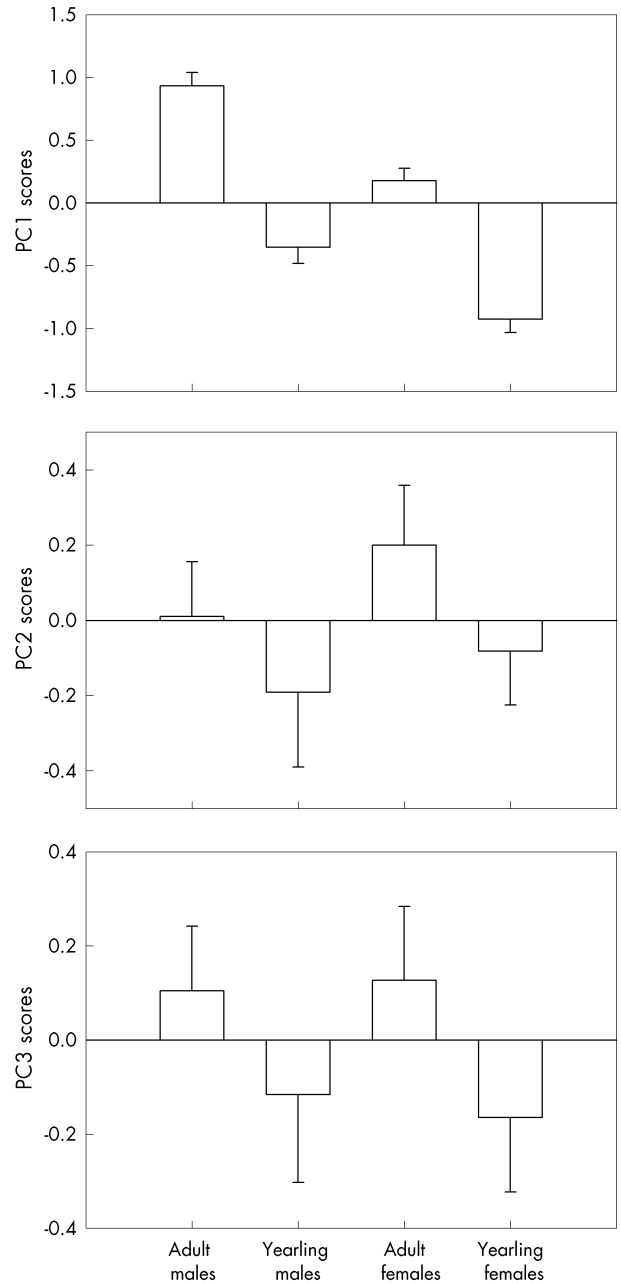

Figure 2. Mean scores for the three Principal Component axes by sex and age of Southern Grey Shrikes in northern Spain. Error bars: ± standard error.

Table 1. Average values (± standard deviation [sd]) of the variables measured in the Southern Grey Shrike in northern Spain according to sex and age with, in brackets, the sample size and range of values. Measurements are in mm, weight in g. WP: white on primaries. WR: white on rectrices. 3P: third primary.

	Males		Females		
	adults	yearlings	adults	yearlings	All birds
Wing	106.30 ± 1.53 (51; 104–111)	103.45 ± 1.35 (30; 100–106)	105.64 ± 1.63 (44; 102–109)	102.65 ± 1.74 (49; 99–106)	104.61 ± 2.22 (174; 99–111)
WP	55.16 ± 1.73 (48; 52.2–59.5)	54.35 ± 1.47 (28; 51.5–57.5)	54.91 ± 1.12 (43; 53.0–58.0)	53.08 ± 1.64 (48; 49.5–56.5)	54.65 ± 1.92 (167; 49.5–59.5)
3P	80.38 ± 1.54 (49; 77.5–84.0)	77.89 ± 1.85 (29; 74.0–82.0)	79.50 ± 1.56 (43; 75.5–82.0)	77.60 ± 1.25 (47; 75.0–80.0)	78.95 ± 1.92 (168; 74.0–84.0)
Tail	116.78 ± 2.80 (48; 112.0–125.0)	112.60 ± 2.63 (29; 107.0–117.0)	114.02 ± 2.23 (43; 108.0–118.0)	110.30 ± 3.34 (48; 101.0–118.0)	113.50 ± 3.74 (168; 101.0–125.0)
WR	49.33 ± 5.21 (48; 34.0–58.0)	47.62 ± 5.00 (28; 37.5–55.5)	45.40 ± 3.50 (43; 39.5–53.5)	45.38 ± 4.29 (46; 29.2–53.5)	46.91 ± 4.81 (165; 29.2–58.0)
Bill length	14.13 ± 0.64 (51; 12.65–15.53)	14.07 ± 0.59 (30; 13.05–15.04)	13.90 ± 0.63 (44; 12.49–15.30)	13.78 ± 0.63 (49; 12.55–15.13)	13.96 ± 0.64 (174; 12.49–15.53)
Bill depth	8.94 ± 0.19 (51; 8.39–9.30)	8.86 ± 0.21 (30; 8.46–9.25)	8.88 ± 0.20 (43; 8.44–9.30)	8.83 ± 0.21 (49; 8.37–9.45)	8.88 ± 0.20 (173; 8.37–9.45)
Bill width	6.82 ± 0.23 (51; 6.37–7.22)	6.83 ± 0.28 (30; 6.30–7.50)	6.92 ± 0.31 (43; 6.40–7.56)	6.80 ± 0.28 (49; 6.00–7.35)	6.84 ± 0.27 (173; 6.00–7.56)
Tarsus	29.92 ± 0.57 (51; 28.72–31.43)	29.71 ± 0.69 (30; 28.16–30.90)	29.88 ± 0.65 (44; 28.23–31.49)	29.78 ± 0.59 (49; 28.30–31.24)	29.83 ± 0.62 (174; 28.23–31.49)
Middle toe	20.46 ± 0.65 (49; 18.09–21.95)	20.40 ± 0.63 (29; 19.14–21.75)	20.70 ± 0.56 (42; 19.71–21.75)	20.51 ± 0.62 (48; 18.50–21.48)	20.52 ± 0.62 (168; 18.09–21.95)
Weight	62.26 ± 2.84 (51; 55.5–69.5)	61.56 ± 2.92 (30; 56.5–68.5)	63.98 ± 2.61 (40; 58.5–69.0)	63.17 ± 2.57 (47; 57.0–69.5)	62.80 ± 2.84 (168; 55.5–69.5)

age codes 4 or 6) and lacked colour contrast on the wing feathers as a result of a complete moult in summer after breeding (Svensson 1992). These criteria were validated by comparing birds of known age that had been ringed as nestlings.

Sex determination

Blood samples (0.1 ml) were obtained by brachial venipuncture and placed on FTA® Classic Cards until DNA extraction, according to Gutiérrez-Corchero *et al* (2002). DNA sequences corresponding to the Chromo-Helicase-DNA-Binding (CHD) protein (present in Z and W sex chromosomes) were amplified using the Polymerase Chain Reaction (PCR). PCR fragments were separated by gel electrophoresis on a 2.5% agarose gel, viewed under UV light and photographed (Gutiérrez-Corchero *et al* 2002). According to Griffiths *et al* (1998), blood samples with one DNA band (corresponding to the CHD-Z gene) indicate males, and samples with two bands (corresponding to CHD-Z and CHD-W genes) are females.

Table 2. Two-way ANOVA (sex, age) in Southern Grey Shrikes in northern Spain. **P* < 0.05, ***P* < 0.01; ****P* < 0.001; ns: not significant.

		Sex		Age		Sex x Age	
	df	F	*P*	F	*P*	F	*P*
Wing	1,170	8.64	**	140.06	***	0.08	ns
WP	1,163	26.98	***	56.36	***	0.003	ns
3P	1,164	5.94	*	82.31	***	1.52	ns
Tail	1,164	32.54	***	79.33	***	0.26	ns
WR	1,161	18.27	***	1.43	ns	1.36	ns
Bill length	1,170	7.02	**	0.81	ns	0.06	ns
Bill depth	1,169	2.16	ns	3.76	ns	0.10	ns
Bill width	1,169	0.53	ns	1.55	ns	2.15	ns
Tarsus	1,170	0.03	ns	2.72	ns	0.33	ns
Middle toe	1,164	3.25	ns	1.55	ns	0.48	ns

Table 3. Results of the Principal Component Analysis (PCA) on morphometric measurements of Southern Grey Shrikes in northern Spain.

	PC1	PC2	PC3
Wing	0.86	0.07	0.14
WP	0.78	0.19	-0.02
3P	0.85	-0.02	0.14
Tail	0.82	-0.06	0.10
WR	0.50	-0.02	0.02
Bill length	0.22	0.35	0.42
Bill depth	0.22	0.00	0.70
Bill width	-0.10	0.09	0.81
Tarsus	0.08	0.78	0.09
Middle toe	-0.09	0.80	0.05
Eigenvalues	3.15	1.46	1.41
% variance	31	15	14

Data analysis

The variables in this analysis were all normally distributed (Kolmogorov–Smirnoff test). We used a MANOVA to analyse the total biometric differences between sexes and age groups, and an ANOVA to analyse difference within each variable. Finally, a Principal Components Analysis (PCA) was carried out to summarise the biometrical characteristics of the Southern Grey Shrike sample. The PC scores of each factor were used to compare the different groups. All statistical analyses were carried out using SPSS version 7.5.

RESULTS

There were significant differences in biometric measurements between the sex and age classes of the Southern Grey Shrike (Table 1). According to the MANOVA, males were larger than females (Wilks λ= 0.72, $F_{10,149}$ = 5.79, $P < 0.001$) and adults larger than juveniles (Wilks λ = 0.45, $F_{10,149}$ = 18.17, $P < 0.001$). There was no interaction between sex and age (Wilks λ = 0.94, $F_{10,149}$ = 0.80, $P = 0.627$), showing that the sex differences in size were consistent in both age groups.

Table 4. Two-way ANOVA (sex, age) on overall PCA scores of the Southern Grey Shrike. In all cases df = 1,158. **P* < 0.05, ***P* < 0.01; ****P* < 0.001; ns: not significant.

	Sex		Age		Sex x Age	
	F	*P*	F	*P*	F	*P*
PC1	34.95	***	112.81	***	0.64	ns
PC2	0.83	ns	2.30	ns	0.06	ns
PC3	0.009	ns	2.56	ns	0.05	ns

Analysis of each variable separately (ANOVA), showed that wing length, 3P, WP and tail were larger in males and adults (Table 2). Likewise, bill length and WR were significantly larger in males than in females, but there was no significant difference between adults and juveniles. There was no interaction between sex and age for any variable (Table 2). Despite these differences, there was a substantial overlap between the measurements in the four groups.

The PCA was used to group the biometric variables. A set of three factors explained 60% of the total variation (Table 3). The first factor (PC1) was related to the wing, WP, 3P, tail and WR, where males and adults were significantly larger than the females and juveniles, respectively (Table 4). The second factor (PC2) was related to the tarsus and middle toe and the third (PC3) involved the bill (width, depth and length), but neither of them were significantly different between sex and age classes (Fig 2).

DISCUSSION

The biometric variation between sex and age classes of the Southern Grey Shrike was similar to other Passeriformes, in that male adults were the largest and female juveniles the smallest (Nilsson 1992, Borras *et al* 1998, Lezana *et al* 2000). Our observation of a sexual dimorphism in size is in contrast to data obtained from the central-west area of the Iberian Peninsula, where a sample of 35 live animals analysed by Infante & Peris (2004) showed no apparent differences between the sexes. However, those authors did not take into account the age of the birds, which is likely to have had an important effect on the results. The data reported here show that if age is taken into account there are significant differences in size between the sexes.

Two theories have been proposed to explain sexual size dimorphism: ecological divergence and sexual selection (Selander 1966, 1972). The ecological divergence theory proposes that size differences are due to differential niche use. On the other hand, the theory of sexual selection proposes that a larger body size in one sex confers advantages in intrasexual competition for mates. Outside the breeding period, male and female Southern Grey Shrikes exploit different habitats: males remain on the breeding territories while females leave to occupy other areas (De la Cruz *et al* 1990, Yosef 1992). In the Great Grey Shrike, differences in individual diets have been correlated with wing and tail lengths, suggesting that those phenotypic characteristics indicate the use of specific trophic niches (Hromada *et al* 2003). On the other hand, in the Southern Grey Shrike, the wings and tail are used actively during courtship displays and territorial disputes (Harris & Franklin 2000) and previous studies with shrikes have already suggested that longer wing and tail lengths can provide a selective advantage in mate attraction (Takagi 1999). Clearly, both differential niche use and sexual selection may explain sexual size dimorphism in Southern Grey Shrikes.

The wing and tail lengths of juveniles of both sexes were shorter than adults, a common phenomenon in Passeriformes (Alatalo *et al* 1984, Nilsson 1992, Merom 1999). However, in species of migratory shrikes where a complete post-juvenile moult takes place in winter (*eg* Bull-headed Shrike *Lanius bucephalus* and the Red-backed Shrike *L. collurio*), only female juveniles have shorter wing and tail lengths than adults, not juvenile males (Jakober & Stauber 1980, Takagi 1999). It has been observed that the capture rate, capture efficiency, prey size or handling time improve with age in avian predators (Ashmole & Tovar 1968, Recher & Recher 1969), indicating that there is an important learning component in foraging behaviour. Craig (1978), in a study of the Loggerhead Shrike, found a decrease in foraging success where there were more juveniles in the population. Similarly, Yosef & Pinshow (2005) concluded that experience can be important in the development of impaling behaviour in shrikes. Juvenile Southern Grey Shrikes fend for themselves during the last stages of wing and tail growth immediately after fledging; as has been suggested for sedentary bird species (Nilsson 1992), a poorer nutritional status in juveniles as a result of inefficient foraging techniques may explain their shorter wing and tail lengths compared to adults.

Several of the biometric results from this study are similar to analyses of the Loggerhead Shrike (Slack 1994, Collister & Wicklum 1996), including the difference in wing, tail and bill between sex and age classes, the greater extent of white on the wing and tail of males and the large overlap in size measurements. This suggests that, at least in terms of biometry, the Southern Grey Shrike is more similar to the Loggerhead Shrike than to the Great Grey Shrike. The latter has sexually dimorphic plumage (Schön 1994), but there are no differences in biometric measurements between sexes (Table 5). Genetic data have also suggested that the Southern Grey Shrike is more closely related to the Loggerhead Shrike than to the Great Grey Shrike (Lefranc & Worfolk 1997).

There is still debate concerning the differences between the Southern Grey Shrike and the Great Grey Shrike and information based on the biometry of live birds is scarce. More research is necessary to allow a detailed comparison of the biometry between different subspecies of this group and to help clarify the taxonomy of these closely related species. In particular, studies on sex-specific differences in foraging behaviour and diet, and the pair bonding system, are needed to discover whether the sexual size dimorphism in the Southern Grey Shrike is determined more by ecological factors or by sexual selection.

Table 5. Mean values (± sd) of biometric measurements (in mm) in other species of shrikes closely related to Southern Grey Shrike with, in brackets, sample size and range of values. WP: white on primaries. WR: white on rectrices.

Species	Sex	Wing	WP	Tail	Bill length	Tarsus	WR	Source
L. excubitor (Netherlands)	males	113.8 ± 2.20 (35; 108–118)		109.1 ± 3.44 (35; 102–116)	13.1 ± 0.43 (21; 12.4–13.8)	27.4 ± 1.14 (20; 26.0–28.8)		Skins: Cramp & Perrins 1993
	females	112.6 ± 2.38 (38; 108–117)		107.5 ± 3.86 (9; 101–114)	13.5 ± 0.74 (8; 12.5–14.4)	31.1 ± 1.22 (8; 29.6–32.5)		No significant difference between sexes
L. ludovicianus (Alberta, USA)	males	97 ± 8 (62)	55 ± 3 (62)	100 ± 4 (61)	11.9 ± 0.8 (62)		34.8 ± 4.4 (39)	Live birds: Collister & Wicklum 1996
	females	95 ± 2 (69)	53 ± 2 (69)	96 ± 3 (66)	11.5 ± 0.6 (68)		31.4 ± 4.2 (44)	Significant difference between sexes

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