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Sex differences in body measurements of Rock Partridges *Alectoris graeca saxatilis* inhabiting the southern French Alps

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Abstract - The sexual dimorphism in size was investigated in a galliform species with monomorphic plumage, the Rock Partridge (*Alectoris graeca saxatilis*), by measuring five morphological variables on 90 males and 90 females collected in the southern French Alps during autumn hunting seasons 1985 to 1995. The sex of all birds was determined by internal examination of the gonads. For all variables, males were significantly heavier and larger than females, whatever the age class (adults *vs.* juveniles).
We also sought external criteria that would reliably separate male and female juveniles before the hunting season, using discriminant analysis of morphological measurements taken at weekly intervals on 106 hand-reared birds of known ages. Juveniles could be correctly sexed 90-100 % of the time at 8, 12 and 18 weeks of age by discriminant models containing 2-3 variables, i.e. body mass and tarsus length together or in combination with wing length or circumference of the head at the level of the eyes. Because hand-reared birds were a little heavier and larger than wild ones, discriminant equations developed for determining the sex of juveniles could not be applied to wild individuals. Sex criteria derived from measurements of captive birds will have to be tested in the wild.

Introduction

The Rock Partridge (*Alectoris graeca*) is a galliform species widely distributed in southern Europe, throughout the Alps, the central and southern Apennines, Sicily and the Balkan Peninsula as far east as central Bulgaria. Its population status in Europe is considered "vulnerable" (Bernard-Laurent and Boev 1997). The Rock Partridge is a highly prized gamebird and occupies an important place in the international scheme to conserve biodiversity. This conservation in turn depends on management decisions, some of which are based on sexual differences either in habitat requirements or in vulnerability to mortality factors. Criteria for distinguishing the sexes are therefore important for both research and management of the species.

Like all *Alectoris* species, Rock Partridges are sexually monomorphic in plumage. At maturity, males are generally larger than females, but the extent of this dimorphism has not been well documented. In Rock Partridge, adult males can be distinguished from adult females by the presence of a tarsal spur on each shank, females having no spur, or rarely, an unique spur. But the presence or absence of spurs is not a valid indicator of sex in birds less than 8 months old because many juvenile males lack spurs. There is currently no reliable technique for externally sexing juveniles. The first objective of this study was to report a large data set of Rock Partridges of known sex from the alpine subspecies *A. g. saxatilis* and to identify the degree of sexual size dimorphism with several body measurements.

The second was to seek valid criteria for sex determination in juveniles before the hunting season. These criteria could not be developed by collecting young in the wild, owing to the difficulty of obtaining authorization to collect birds outside the hunting season. Neither could they be developed by marking and recapturing chicks in the wild, because populations are sparse and birds occupy steep rocky habitats. Consequently, sex identification in juveniles was studied by taking morphological measurements on hand-reared birds.

Materials and methods

Collection and analysis of wild birds

We examined 180 Rock Partridges (90 males, 90 females) shot during the hunting season (end of September to 11 November) between 1985 and 1995 in different mountain areas within a 50 km area of the

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southern French Alps. The sex of individuals was determined by examination of the gonads. Birds were aged as adults or juveniles according to the aspect of the two outer primaries: in autumn tips of outer primaries 9 and 10 are pointed in juveniles and rounded in adults (Glutz von Blotzheim *et al.* 1973). Moreover during the hunting season, primaries 9 or 10 are often still growing in adults but never in juveniles. Because the hatching period extends from early July to early August and because the partridges were shot between 23 September and 11 November, juveniles collected during hunting season included birds of various ages. Their ages, estimated with an accuracy of one-week by examination of the stage of primary feather moult were 9 to 17 weeks old, except for one individual of 6 weeks old (Soyez 1994).

Three body measurements were made: body mass, measured to the nearest 5 g, using a Pesola spring balance; wing length, measured to the nearest mm from the wrist joint to the tip of the longest primary, with the wing in a flat and straightened position; and total body length, measured to the nearest mm from the tip of the bill to the tip of the tail with the bird lying on its back.

Two additional measurements, the tarsal length and the circumference of the head, were made on only a few birds examined during the last two hunting seasons, to make comparisons with hand-reared birds. To measure tarsal length (to the nearest 0.5 mm), the leg was bent to 90° at the joint between the tibia and the metatarsus, and the middle toe was bent to 90° in the opposite direction. Tarsal length (to the nearest 0.5 mm) was the straight-line distance between the back edge of the tibia and the top of the middle toe. The circumference of the head was measured to the nearest mm at the level of the eyes.

Measurements on hand-reared birds

Because rearing of Rock Partridges in captivity in France is forbidden, the Office National de la Chasse et de la Faune Sauvage (ONCFS) purchased 22 chicks of the alpine subspecies *A. g. saxatilis* from a game farm in Asiago (Italy). During the next two years, they were bred and raised in captivity at the ONCFS farm in Verzé (France). At all 106 partridge chicks were individually ringed at 7 days of age. Sex of juveniles was established the next spring after hatching by cloacal examination and by the presence or absence of spurs.

Like for wild birds, we measured body mass, tarsal length and head circumference. "Total length" was not measured on live birds. The length of the primary number 9 was considered to be "wing length" in young birds. Unfortunately the tip of the ninth primary was broken in many birds 12 weeks of age or older. Consequently wing length data were insufficient in the discriminant analysis from of the age of 12 weeks. For adults, wing length was measured in the same way as in wild birds.

Measurements were taken on young birds at 5, 6, 7, 8, 9, 12, 14, 15, 18, 20, 21, 22 and 25 weeks of age, on subadults 8 to 10 months old, and adult males and females at the ages of 18 months and 30 months. All measures on captive birds were taken by the same person (D. Soyez).

Statistical analysis

For wild birds, sex differences in body measurements could not be analysed using a two-factorial analysis of variance, because of the great heterogeneity of variances between the four sex-age categories. Therefore, mean differences in morphological variables between sexes were analysed separately for each age class (adults *vs.* juveniles) using Student's *t* test for variables after checking the normality hypothesis (Kolmogorov-Liliefors normality test). For variables with data not conforming to a normal distribution, we applied a Mann-Whitney test. All tests were one-sided with $\alpha = 0.05$.

For hand-reared birds, we investigated the combination of morphological variables performing the best separation between sexes by using discriminant analysis (Lebart *et al.* 1995) with the software SPAD version 4.51 (DECISIA corporation). When separating two groups, the discriminant analysis (DA) is equivalent to a multiple regression where the dependent variable (here the sex) takes only two different values (one per group) and the explanatory variables are those of the DA (Lebart *et al.* 1995). Therefore the adjusted coefficient of determination calculated for all possible combinations of explanatory variables was used to help in choosing the best combination, a higher coefficient indicating a likely better model. Only combinations based on measurements of at least 11 birds of each sex were included. The probability of incorrectly determining the sex is known to be optimistic when estimated on the sample used to assess the discriminant model. Therefore, the bootstrap method with 1000 iterations was used to give an unbiased estimate of the probability of incorrectly determining the sex. We excluded the models where more than 10% of males or females were incorrectly sexed in samples or by bootstrap.

Results

Univariate measurements of sex differences in wild birds

Although body mass and length of males and females overlapped somewhat, males were on average heavier

and larger than females, whatever the age class (Table 1). All comparisons between males and females showed highly significant differences for adults (Table 1). The differences between sexes for each variable were as follows in adults:
average body mass in males was 120 g higher than in females,
average wing length in males was 12 mm longer than in females,
average total length in males was 24 mm longer than in females,
average tarsus length in males was 5 mm longer than in females,
average head circumference in males was 11 mm longer than in females.

For juveniles, all differences in morphological variables were also significant, except for head circumference. The probability values of the statistical tests were higher for juveniles than for adults, probably because of the wide age structure of the juveniles (9 to 17 weeks of age) which resulted from both the duration of the hunting season and the extended hatching period. Thus, although males are typically larger than females of the same age, some juvenile males shot at the beginning of the hunting season could be smaller than older juvenile females. The largest differences by sex were in body mass, whatever the age (18.2% and 10.7% respectively for adults and juveniles, Table 1).

Sexing of pen-reared rock partridges using body measurements

Values of the adjusted coefficient of determination were much smaller with one variable than with two or more variables. Therefore any univariate technique to sex Rock Partridge is likely to have low accuracy. The values of the adjusted coefficients of determination were nearly as high with two variables as with three variables. Among all possible combinations of two variables, the highest value of the adjusted coefficient of determination was provided by a combination of body mass and tarsus length, whatever the age.
DA performed on a combination of 2 or 3 variables classified correctly males and females at 8, 12 and 18 weeks of age (Table 2):
At the age of 8 weeks, DA using tarsus length and head circumference measured on 13 males and 16 females assigned approximately 91% of males and 90 % of females to the correct sex. DA using body mass, tarsus length and wing length measured on 12 males and 17 females assigned 90% of males and 92% of females to the correct sex.
At the age of 12 weeks, DA using body mass and tarsus length measured on 13 males and 17 females assigned 91% of males and 99% of females to the correct sex. DA using both criteria plus head circumference measured on the same birds assigned 98% of males and 99% of females to the correct sex ;

Table 1. Comparative body measurements of male and female Rock Partridges from southern French Alps during autumns 1985-1995.

Morphological variable	Adult males				Adult females						
	$\bar{x}$	SE	Range	n	$\bar{\chi}$	SE	Range	n	Difference[b] %	Statistical test[a]	P
Body mass (g)	659	48	520-770	46	539	43	460-650	37	18.2	t = 11.96	<0.0001
Wing length (mm)	171	4.7	160-180	46	159	4,5	149-170	36	7.0	t = 11.26	<0.0001
Total length (mm)	389	16.3	352-430	42	365	19.2	330-400	34	6.2	t = 5.94	<0.0001
Tarsus length (mm)	57	2.3	52.5-59.5	8	52	1.9	48-54	13	8.8	U'= -3.33	0.0004
Head circumference (mm)	107	11.5	92-122	9	96	12.9	80-114	13	10.3	U'= -2.47	0.0067

Morphological variable	Juvenile males				Juvenile females						
	$\bar{x}$	SE	Range	n	$\bar{\chi}$	SE	Range	n	Difference[b] %	Statistical test[a]	P
Body mass (g)	532	76	350-660	46	475	65	220-580	51	10.7	t = 3.87	0.0001
Wing length (mm)	166	6.1	151-181	41	158	5.5	145-174	50	4.8	t = 6.40	<0.0001
Total length (mm)	365	19.6	319-408	38	355	22.0	280-395	48	2.7	t = 2.41	0.0090
Tarsus length (mm)	54	2.2	51.1-58.2	13	51	2.6	47-55	8	5.6	U'=-2.54	0.0056
Head circumference (mm)	100	15.7	72-120	13	93	9.8	78-102	9	7.0	U'= -1.47	0.07

[a] A Student's *t* test, adjusted for unequal variances, was used for comparisons of body mass, wing length and total length and a Mann-Whitney test for comparisons of tarsus length and head circumference.
[b] Relative difference in percentage of the means of each variable between sexes.

At the age of 18 weeks, DA using body mass and tarsus length measured on 22 males and 20 females assigned 90% of males and 98% of females to the correct sex. DA using both criteria and head circumference measured on 11 males and 16 females assigned 90% of males and 100% of females to the correct sex.

At 12 and 18 weeks of age, the accuracy for predicting females was higher than for males, whatever the number of variables (see bootstrap results Table 2). The error for classifying males was very similar whatever the age. The error for classifying females was lower at 12 and 18 weeks of age than at 8 weeks of age.

Thus, two variables, body mass and tarsal length, taken together at 12 and 18 weeks of age or combined with wing length at 8 weeks of age, provided good quality sexing of juveniles at 8, 12 and 18 weeks of age. These three variables can be considered as the best ones for predicting the sex of juveniles.

Can the sex of wild juveniles be determined using measurements on hand-reared birds?

Comparison of three morphological variables between wild and hand-reared adults, within each sex, revealed significant differences, except for the tarsal length of males (Table 3). Hand-reared birds had a higher body mass, longer wings and longer tarsi than wild ones. These differences may be a result of low locomotive activity and of *ad libitum* feeding with commercial food for hand-reared bird. Therefore sexing captured or hunter-harvested juveniles with our discriminant equations is not suitable. Indeed, when applying the sexing method to wild birds, as expected we correctly sexed females, but many males were classified as females.

Discussion

Body measurements

For all measurements, males were larger than females of the same age class. Published data on the biometrics

Table 2. Percent of pen-reared Rock Partridges correctly sexed by a discriminant analysis on combinations of 2 or 3 morphological variables as well as corresponding classifications equations.
Variables include BM = body mass, TL = tarsus length, WL = length of primary 9, HC = head circumference.

Age	Variables	Classification equation	% males correctly sexed		% females correctly sexed	
			sample (*n*)	bootstrap	sample (*n*)	bootstrap
8 weeks	TL, HC	D = 0.802 (TL) + 0.764 (HC) – 106.146	92.3 (*13*)	91.2	93.8 (*16*)	89.9
	BM, TL, WL	D = 0.066 (BM) + 1.354 (TL) – 0.368 (WL) – 49.629	91.7 (*12*)	90.1	94.1 (*17*)	91.7
12 weeks	BM, TL	D = 0.139 (BM) + 1.441 (TL) – 146.437	92.3 (*13*)	90.8	100 (*17*)	99.2
	BM, TL, HC	D = 0.126 (BM) + 1.109 (TL) – 0.560 (HC) – 174.865	100 (*13*)	97.9	100 (*17*)	98.8
18 weeks	BM, TL	D = 0.047 (BM) + 0.0622 (TL) – 60.788	90.9 (*22*)	90.1	100 (*20*)	98.1
	BM, TL, HC	D = 0.092 (BM) + 1.418 (TL) + 0.641 (CT) – 186.837	90.9 (*11*)	89.7	100 (*16*)	99.9

* A calculated value of D > 0 indicates a male.

Table 3. Comparative body mass, tarsal length and wing length measurements, by sex, of wild and hand-reared adult Rock Partridges.

Morphological variable	Wild birds				Hand-reared birds						
	$\bar{x}$	SE	Range	n	$\bar{x}$	SE	Range	n	Difference[b] %	Statistical test[a]	P
Body mass (g)											
Males	659	48	520-770	46	700	67	605-860	32	5.8	t = - 2.97	0.0023
Females	539	43	460-650	37	583	77	450-750	33	7.5	t = - 2.87	0.0030
Tarsal length (mm)											
Males	57.3	2.3	52.5-59.5	8	58.5	2.5	54.5-64	32	2.0	U' = - 0.95	0.172
Females	52.1	1.9	48-54.5	13	54.3	1.4	51.5-58.5	34	4.0	U' = - 3.27	0.0005
Wing length (mm)											
Males	171	4.7	160-180	46	178	6	170.5-191	29	3.9	t = - 5.70	<0.0001
Females	159	4.5	149-170	36	167	4	162-174	30	4.8	t = - 7.52	<0.0001

[a] A Student's *t* test adjusted for unequal variances was used for comparison of body mass and wing length and a Mann-Whitney test for comparisons of tarsal length

of the subspecies *saxatilis* found in the Alps give values of body mass or wing length for a very small number of adults (Table 4). All published ranges of body mass and wing length from the different alpine locations fell within the ranges of these two measurements in our southern Alps population (Table 4). However mean differences in wing length or body mass could not be tested because we lacked complete data from literature and were limited by the small number of birds measured in the different alpine locations.

Sex determination

Pen-reared juveniles can be sexed with reasonable accuracy (≥ 90%) as early as 8 weeks of age by measuring two or three morphological variables, including at least body mass and tarsus length. The accuracy of the models for females is even very good (≥ 98%) at 12 weeks and 18 weeks of age.

Wing length, as measured by the length of primary 9, would probably also be a convenient sex criterion for juveniles, as shown by its contribution to the discriminant model found at 8 weeks of age. Unfortunately the shortage of wing length measurements, due to the damaged tip of the primary 9, prevented us from including this variable in the discriminant analysis of birds at 12 weeks old of age or older. However, in wild birds this measurement would likely contribute to sex recognition.

Various sex criteria have been proposed for other *Alectoris* species. In Red-legged-Partridge (*Alectoris rufa rufa*), a technique to determine the sex of juveniles shot in autumn was described by Pépin (1985) who found that the total body length (from tip of bill to tip of tail) of juveniles was generally longer in males than in females. However it is not practical to take this measurement on live birds. In Chukar Partridge (*Alectoris chukar chukar*), Weaver and Haskell (1968) proposed a field key for rapidly determining the sex of juveniles between 14 to 26 weeks of age, using length of primaries 1 and 3. However this method cannot be applied for an early identification (< 14 weeks) of sex. According to Woodard *et al.* (1986), a single tarsus length measurement is a reliable way of separating the sexes of chukars as early as 8 weeks of age. However, this technique, developed for captive birds, has not been tested in the wild. Thus none of the available techniques for sex determination is entirely satisfactory for either live juvenile Chukars or Red-legged Partridges captured in the wild.

How to validate the sex criteria for wild birds?

Like in the above Chukar's study, criteria used for sexing Rock Partridge juveniles were measured on hand-reared birds which differed from their wild conspecifics in morphological traits. A higher body mass in captive than in wild birds has also been reported in other galliforms, for example in grey partridges

Table 4. Body mass and wing length data* recorded in the literature for adult Rock Partridges from different locations in the Alps.

Locations (reference)	Body mass (g)		Wing length (mm)	
	Male	Female	Male	female
Swiss Alps				
(Glutz von Blotzheim *et al.* 1973)				
$\bar{x}$ (n)			171 (17)	162 (8)
range			166-173,5	160-167
Italian Alps				
(Priolo and Bocca 1992)				
• Val d'Aosta				
$\bar{x}$ (n)	701 (3)	573 (3)	172 (4)	167 (6)
range	670-740	550-590	168-176	158-170
• Carnic Alps				
$\bar{x}$ (n)	617 (3)	552 (3)		
range	610-630	510-585		
Western Alps				
(Cramp and Simmons 1980)				
$\bar{x}$ (n)			171 (8)	162 (13)
range			167-174	157-167
Austrian Alps				
(Hafner 1994)				
$\bar{x}$ (n)	649 (7)	546 (7)	171 (3)	160 (3)
range	580-740	490-620	169-173	159-161

* Measurements were generally taken on hunter-harvested birds, except in Austrian Alps (live-trapped birds).

(Putaala and Hissa 1995) and in pheasants (Robertson *et al.* 1993). Therefore in wild rock partridges the sex criteria still have to be validated. Unfortunately our set of wild juveniles, classified by age and sex, was too small to allow us to test the sex criteria developed on pen-reared birds. To make this test, we suggest that a larger sample of juveniles be obtained during the hunting season. The age of these young could be determined by the technique of Soyez (1994). A sufficiently large sample will require several years, because the recent establishment of shooting plans (Baudin and Magnani 2000) has reduced bags. Considering the increasing participation of French hunters in the management of mountain grouse and partridges (Ellison *et al.* 1994), we feel that such a study for Rock Partridge is feasible. Furthermore, to get a better estimate of accuracy, it would be necessary to test each discriminant model using an independent sample of individuals from another alpine region. For example, birds could be collected in Italy, where the Rock Partridge is also an important gamebird.

If the above external criteria proved to be reliable for sexing wild juveniles, the technique would have management implications in harvest surveys. Indeed the ages of most hunter-harvested juveniles, 9 to 17 weeks, fall within the interval of 8-18 weeks during which prediction of sex was possible with reasonable accuracy. Consequently, if the external criteria were validated, we could expect to get reliable information on the sex composition of the Rock Partridge harvest. Furthermore, the ability to determine the sex of wild juveniles equipped with radio tags would provide important information about sex-related differences in dispersal pattern, habitat use and winter site fidelity, which are still open questions (Bernard-Laurent 1994).

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Résumé - Le dimorphisme de taille en fonction du sexe et de l'âge a été étudié chez la perdrix bartavelle, *Alectoris graeca saxatilis*, galliforme au plumage monomorphique, en mesurant 5 variables morphologiques sur 180 oiseaux (90 mâles, 90 femelles) collectés dans les Alpes françaises du sud pendant les années 1985 à 1995. Le sexe des oiseaux a été déterminé par un examen interne des gonades. Les mâles apparaissent plus grands et plus lourds que les femelles, quelle que soit la classe d'âge (adulte *vs.* jeune).

Nous avons aussi cherché à identifier des mesures corporelles qui permettraient de déterminer le sexe des jeunes oiseaux. Pour cela les mensurations de 4 variables morphologiques relevées sur 106 jeunes, élevés en captivité et d'âge connu, ont fait l'objet d'analyses discriminantes. En utilisant la combinaison de 2 mensurations, la masse corporelle et la longueur du tarse, le sexe des jeunes peut être déterminé avec une bonne précision (90 à 100 %) à l'âge de 12 et de 18 semaines. En ajoutant une troisième variable (la longueur de l'aile pliée ou la circonférence de la tête), la distinction des sexes est possible avec la même précision dès l'âge de 8 semaines. Etant donné que les adultes élevés en captivité se sont révélés être un peu plus lourds et plus grands que les adultes sauvages, les équations discriminantes établies pour la détermination du sexe de jeunes élevés en captivité ne peuvent pas être appliquées à des jeunes oiseaux sauvages. Les critères de distinction des sexes devront être validés dans les populations sauvages.

References

Baudin B. and Magnani Y. 2000. Le petit gibier de montagne. Faune sauvage 251: 202-212.

Bernard-Laurent A. 1994. Plan de restauration pour la Perdrix bartavelle (*Alectoris graeca saxatilis*) en France : mesures de protection et de gestion. - In: Plans de restauration pour quelques galliformes européens: gelinotte, grand tétras, tétras-lyre et perdrix bartavelle - tome 1.- Gibier Faune Sauvage 11, hors série: 309-320.

Bernard-Laurent A. and Boev Z. 1997. *Alectoris graeca* Rock partridge. In: EBCC Atlas of European breeding birds, their distribution and abundance, Hagemeijer W.J.M., Blair M.J., eds. London: T.A.D. Poyser: 207.

Cramp S., and Simmons K.E.L. 1980. Rock partridge. In: Handbook of the birds of Europe, the Middle East and North Africa. The birds of the western Palearctic. Vol. II. - Oxford, Oxford University Press: 458-463.

Ellison L., Menoni E., Bernard-Laurent A. and Magnani Y. 1994. Participation des chasseurs français à la gestion des galliformes de montagne. In: Plans de restauration pour quelques galliformes européens: gelinotte, grand tétras, tétras-lyre et perdrix bartavelle - tome 1. Gibier Faune Sauvage 11, hors série: 333-348.

Glutz von Blotzheim U.N., Bauer K.H. and Bezzel E. 1973. Handbuch der Vögel Mitteleuropas. Band 5, Galliformes und Gruiformes. - Frankfurt am Main, Akademische Verlagsgesellschaft.

Hafner F. 1994. Das Steinhuhn in Kärnten. Ökologie, Verhalten und Lebensraum. Carinthia II, Sonderheft 52, Naturwissenschaftlicher Verein für Kärnten.

Lebart L., Morineau A. and Piron M. 1995. Statistique exploratoire multidimensionnelle. Dunod, Paris.

Pépin D. 1985. Morphological characteristics and sex classification of Red-legged Partridge. J. Wildl. Manage. 49 (1): 228-237.

Priolo A., and Bocca M. 1992. Coturnice *Alectoris graeca* (Meisner 1804). - In: Brichetti et al. (eds), Fauna d'Italia xxix, Calderini Ed., Bologna: 766-777.

Putaala A. and Hissa R. 1995. Effects of hand-rearing on physiology and anatomy in the grey partridge. Wildl. Biol. 1: 27-31.

Robertson P.A., Wise D.R. and Blake K.A. 1993. Flying ability of different pheasant strains. J. Wildl. Manage. 57 (4): 778-782.

Soyez D. 1994. Détermination de l'âge des jeunes perdrix bartavelles (*Alectoris graeca saxatilis*) et rochassières (A. *graeca saxatilis* x A. *rufa rufa*) par l'examen de la mue des rémiges primaires. Gibier Faune Sauvage, Game Wildl. Vol.11, sept. :185-206.

Weaver H.R. and Haskell W.L. 1968. Age and sex determination of the chukar partridge. J. Wildl. Manage. 32 (1): 46-50.

Woodard A.E., Hermes J.C. and Fuqua L. 1986. Shank length for determining sex in chukars. Poultry Science 65: 627-630.