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Sexing Serin *Serinus serinus* fledglings by plumage colour and morphometric variables

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Abstract

Identifying the sex of fledglings may be crucial in many ecological bird studies. However, in many passerine species, fledglings show a typically streaked, brownish plumage which prevents discrimination of sexes. In this paper we test the usefulness of plumage colour (in conjunction with morphometric variables) to sex Serin fledglings. The data are based on 904 Serin fledglings (EURING age 3J) captured in the suburban area of Barcelona (NE Spain) from 1993 to 1996. Of these, 175 were recaptured and the sex confirmed. Variables used included: plumage colour (a six values visual score from very greyish-brown to very ochreous-brown, and quantitative data from a digital chromameter), days since 1st of March (to compensate for incomplete feather growth), length of wing, tail and culmen, width and depth of bill, body mass, length of first and third primary, and the five first components of a Principal Components Analysis of the biometric variables. We also included the interaction between the variables. The results showed that female fledglings tend to have a greyish-brown plumage colour, whereas males display an ochreous-brown plumage, characterised by a higher saturation of colour on back and breast, and a generally more yellowish hue. According to logistic regression, 83% of Serin fledglings can be correctly sexed by wing length, plumage colour, date and the interaction between wing-length and date.

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Introduction

Sexing of fledglings may be crucial in many ecological bird studies, as for instance when investigating differential parental investment, dispersal of young, or mortality among males and females during their early stages (Payne 1991, Breitwisch 1989, Gowaty 1993, Marzluff & Balda 1989, Stamps 1990, Weatherhead & Teather 1991, Blank & Nolan 1983). However, in many passerine species researchers can face an important methodological constriction because fledglings show a standard streaked, brownish plumage which prevents sexing (Svensson 1992, Busse 1984, Pyle et al. 1987).

In a previous paper (Borras et al. 1993) we demonstrated the presence of plumage dichromatism in Citril Finch *Serinus citrinella* fledglings. Females tended to show a greyish-brown colour, whereas males displayed an ochreous-brown plumage. We suggested that this dichromatism could be common also in other cardueline species. In this paper we test the usefulness of plumage colour (in conjunction with morphometric variables) to sex Serin *Serinus serinus* fledglings. Additionally, we validate qualitative fledgling colour categories, used in the field by visual inspection, with quantitative data obtained with a chromameter.

Material and methods

Data presented here are based on 904 Serin fledglings (EURING age 3J) captured at a permanent ringing station in the suburban area of Barcelona (NE Spain) from 1993 to 1996. Age was determined according to Svensson (1992), and each bird was ringed for individual recognition with aluminium rings. We scored the plumage colour of the birds along a visual scale with six qualitative categories (very greyish, greyish, slightly greyish, slightly ochreous, ochreous, very ochreous), which we later transformed to a semi-quantitative scale, from very greyish (value 1) to very ochreous (value 6). We also measured length of wing (maximum chord), tail and tarsus, following Svensson (1992), length of first and third primary, the primaries counted ascendently, following Jenni & Winkler (1989). All measurements were obtained by the same investigator. In 1997, we additionally measured fledgling colour of the breast (112 birds) and back (109 birds) using a CR-200, Minolta chromameter with an eight mm diameter sensor and standard illumination set to D_{65} (6504K). The chromameter provides, for each bird, colour measurements according to different systems (e.g. Munsell, CIE Y_{xy}, CIE Lab, CIE LCH). Here we use the CIE LCH colour system which provides independent values of hue, chroma, and lightness, the parameters generally used to define a colour. Hue corresponds to wavelength of light: blue for short, red for longer wavelengths. In the CIE LCH system, however, hue is transformed to cylindrical coordinates: 0° refers to pure red, 90° to pure yellow, 180° to green, 270° to pure blue, and 360° (=0°) again to pure red. Therefore, for instance, a colour with a hue angle of 45° is orange. Chroma, also called saturation or intensity, refers to spectral variance, and therefore to colour purity; the more monochromatic a colour is, the higher its chroma value. Lightness, also called brightness, is correlated with physical light intensity and refers to percentage of white, or what is the same, position on a grey-scale between black and white (Rowland 1979, Booth 1990). Differences in these three values among the six visual colour categories were analysed using a non-parametric ranked MANOVA (Conover 1981).

From the whole sample of 904 fledglings, 175 (98 males and 77 females) were later recaptured after completion of body moult, so that sex could be determined according to plumage characters (Svensson 1992). These birds form the sample included in the analysis. We used logistic regression to determine the variable or group of variables that predicted more accurately the sex of the majority of birds. The variables that we used were date (days since 1 March), length of wing, tail and culmen, width and depth of bill, body mass, length of first and third primary, and the five first components from a Principal Components Analysis on the different biometric variables. We also included the interaction between the variables. The variable date could be important because fledglings of both sexes captured in the beginning of the reproductive season are likely to have less than fully developed wing feathers, increasing the probability of some males being classified as females. The different models of sex discrimination were evaluated by the use of the Akaike Information Criterion, AIC (Akaike 1973).

In order to arrive at more reliable sexing when using only wing length and date, we used an additional sample of 531 fledglings whose sex had been confirmed by recapture after moult (from a total of 1210 ringed birds) captured from 1985 to 1992, when only these two measures were obtained. The conclusions from the 1993–1996 sample were not contradicted by the results from this older sample.

Results

The qualitative fledgling colour categories used in the field by visual inspection showed significant differences in colour saturation (chroma) and hue values of breast and colour saturation values of back (Ranked MANOVA Wilks' Lambda=0.40, Rao's R=3.40, df1=30, df2=394, P<0.001) (Table 1). The more ochreous a bird was, the higher were values of colour saturation on breast and back , and the more yellow was the hue on thre breast (Table 2).

Of the morphometric variables measured, wing-length, tail-length, and length of third primary showed significant (P<0.05) differences between the sexes (Table 3). The five best models, according to the AIC values, to sex Serin fledglings from logistic regression analysis of the different biometric variables, including colour and date, are presented in Table 4.

Table 1. Results of ranked MANOVA comparing colour components of brest and back feathers measured by chromameter and estimated among six qualitative visual categories from very greyish to very ochreous.

Jämförelse mellan bröst- och ryggfjädrarnas färgegenskaper mätt med en kromometer och uppskattade med en visuell, sexgradig skala från mycket grå till mycket gul (rankad MANOVA).

Variable	df	F	P
Breast *Bröst*			
Lightness *valör*	5.106	2	=0.09
Chroma *renhet*	5.106	12.97	<0.001
Hue *kulör*	5.106	6.28	<0.001
Back *Rygg*			
Lightness	5.103	0.39	=0.85
Chroma	5.103	2.68	<0.05
Hue	5.103	1.27	=0.28

Table 2. Values (Mean ± Standard deviation) obtained with the chromameter for the three significant (see Table 1) qualitative visual colour categories of fledgling breast and back feathers.

Värden (medelvärde ± standaravvikelse) erhållna med kromometer för de tre signifikanta (se Tabell 1) kvalitativa visuella färgkategorierna hos ungfåglarnas bröst- och ryggfjädrar.

Colour categories *Färgkategori*	Breast *Bröst*			Back *Rygg*	
	Chroma	Hue	n	Chroma	n
very ochreous *mycket gul*	16.8±3.52	91.7±4.0	6	11.5±2.28	6
ochreus *gul*	12.0±2.5	89.3±3.13	37	9.4±1.68	36
slightly ochreous *svagt gul*	10.4±3.6	86.5±5.99	29	9.9±2.03	28
slightly greyish *svagt grå*	8.5±1.74	84.3±3.62	10	8.7±1.44	10
greyish *grå*	9.7±7.58	84.5±6.31	22	9.1±1.88	21
very greyish *mycket grå*	6.7±2.29	82.1±7.79	8	8.3±1.29	8
all categories *alla kategorier*	10.7±4.66	86.8±6.66	112	9.4±1.9	109

Tabel 3. Means of morphometric variables for female and male fledgling Serins. N = 77 females and 98 males.

Medelvärden för morfologiska variabler hos honor och hanar av gulhämpling. N = 77 honor och 98 hanar.

Variable	Females Mean	*Honor* SD	Males Mean	*Hanar* SD	t	P
Wing length *Vinglängd*	69.4	1.47	72.1	1.57	11.60	<0.001
Tail length *Stjärtlängd*	47.8	1.80	49.4	1.79	5.89	<0.001
Tarsus length *Tarslängd*	14.0	0.59	14.1	0.54	1.22	0.22
Third primary *3:e handpennan*	54.7	1.49	56.6	1.33	9.19	<0.001
First primary *1:a handpennan*	6.6	0.67	6.7	0.77	0.84	0.40

Table 4. The five best logistic regression models (ordered by AIC) for sexing Serin fledglings based on morphometric variables. Wing refers to wing-length, colour to plumage colour based on a semi-quantitative 6 values scale, date to number of days from 1 March. N = 98 males and 77 females.

De fem bästa logistiska regressionsmodellerna (ordnade efter AIC) för könsbestämning av unga gulhämplingar med hjälp av morfologiska variabler. Wing avser vinglängd, colour fjädrarnas färg enligt en halvkvantitativ sexgradig skala, date antalet dagar från 1 mars. N = 98 hanar och 77 honor.

AIC	Model			
157.917	wing	colour	wing*date	date
158.361	wing	—	wing*date	date
162.563	wing	—	—	date
162.672	wing	colour	—	—
162.763	wing	—	wing*date	—

variables are shown in Table 5. The best logistic regressions for sex determination were:

Sex = -0.7105*wing-length + 0.23636*plumage-colour - 0.96551*date + 0.013531*wing-length*date +50.84.

Sex = 0.84322*wing-length - 0.05616*date + 0.00075887*wing-length*date + 58.7786.

Given the predictions of sex obatined by the use of wing-length alone, we also provide the logistic regression related to this variable:

Sex = 0.94963*wing-length – 66.6431.

When we replace in each formula the specific values for each variable of a given individual, a positive sex value means that the bird is probably a male, and a negative value that it is probably a female. For example, and in the third equation, wing-length values smaller than 70 mm will be discriminated as females (i.e. the output is a negative sex value), and those larger or equal to 70 mm as males (i.e. the output is a positive sex value).

Table 5. Percentage of correctly sexed Serin fledglings, and percentage of males and females among the correctly sexed birds in each sample according to the logistic regression model used.

Procenten rätt könsbestämda ungfåglar av gulhämpling samt procenten hanar och honor bland de rätt könsbestämda fåglarna i varje stickprov enligt den logistiska regressionsmodellen.

Model			Correctly classified: *Korrekt bestämd:*	sex *kön*	males *hanar*	females *honor*	n
wing				80.9	59	41	706
wing	date			80.9	59	41	706
wing	date	wing*date		80.9	59	41	706
wing	date	wing*date	colour	82.9	56	44	175

The two models having the lowest AIC values included (1) wing-length, colour, date, and the interaction between wing-length and date, and (2) wing-length, date, and the interaction between wing-length and date. All other models had AIC values more than four units higher than the best model. This difference exceeds the minimum of 2–3 units difference considered to represent substantial improvement of model performance (D. R. Anderson, pers.comm.). The use of wing-length and date allowed correct sexing of 80.9% of the fledglings. The inclusion of plumage only increased the accuracy of sexing to 82.9% (Table 5). The predictive values of single

Discussion

Our results show that Serin fledglings are dichromatic, which supports our earlier suggestion that this dichromatism for sexing may be extended to other species, especially cardueline finches (Borras et al. 1993). Females tend to show a greyish-brown colour, whereas males display an ochreous-brown plumage, characterized by a higher saturation (i.e. chroma) of colour in back and breast, and generally a more yellowish hue.

The use of wing length alone allowed sex discrimination of about 81 per cent of Serin fledglings. Given the easiness of measuring wing-length, and the predictions of sex obtained by the use of this variable alone, we think it may be reasonable to use only this in most analyses. The inclusion of date did not increase the percentage of correctly sexed birds. However, and according to AIC, date (and its interaction with wing-length) appears in the two models best supported by the data (Burnham & Anderson 1992). This suggests that date may be an important variable, probably because fledgling males captured during the first days in the season have not yet fully developed wing feathers, which may cause a date-dependent error. This would of course not be a problem for females. The addition of plumage colour as a criterion improved sexing to 83%. However, improvement in AIC with respect to the previous model (wing-length, date, wing x date) was less than the suggested 2–3 units (D. R. Anderson, pers.comm.). The importance of colour, although statistically significant, is therefore less than in the Citril Finch (Borras et al. 1993).

Finally, we would like to point out the usefulness of a digital chromameter for field measurement of colour variables, and particularly for the validation of visual scales. Such visual scales may then be of more general use for most field workers, given the high cost of the digital chromameter.

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Sammanfattning

Könsbestämning av unga gulhämplingar Serinus serinus *med hjälp av dräktfärg och morfologiska variabler*

Att kunna könsbestämma ungfåglar så snart som möjligt efter det att de lämnat boet är viktigt, t.ex. för att studera hur mycket föräldrarna anstränger sig i vården av ungar av olika kön, ungfåglarnas spridning eller dödligheten bland unga hanar och honor. Ofta är detta svårt på grund av att ungfåglar av båda könen har en likartad brunaktig, streckad fjäderdräkt.

Vi har dock tidigare i citronsiskans ungfågeldräkt funnit färgskillnader mellan könen. Hanarna var mera gulbruna och honorna mera gråbruna. I denna uppsats undersöker vi om det även hos gulhämplingens ungfåglar finns en liknande skillnad som skulle kunna använda vid könsbestämning. Vi jämför resultaten med morfologiska skillnader och jämför också kvalitativ färgbestämning med hjälp av en visuell skala med kvantitativ färgmätning med instrument.

Vårt material består av 904 unga gulhämplingar (EURING kod 3J) som fångats nära Barcelona mellan 1993 och 1996. De åldersbestämdes enligt Svensson (1992) och ringmärktes. Vi registrerade också dräktfärgen enligt en visuell, sexgradig skala (mycket grå, grå, svagt grå, svagt gul, gul, mycket gul) samt mätte längden på vinge, stjärt och tars samt första och tredje handpennan. Samme person gjorde alla mätningar. Med en Minolta CR-200 kromometer bestämde vi färgen på bröstet (112 fåglar) och ryggen (109 fåglar). Av flera system använde vi det med beteckningen CIE LCH som ger värden på tre olika färgegenskaper: färgton (kulör), färgrenhet (färgmättnad) och valör (gråskala, ljushet). Av de 904 ungfåglarna återfångades senare 175 (98 hanar och 77 honor) efter fullbordad ruggning, varvid säker könsbestämning kunde ske. Det är dessa 175 fåglar som vi utnyttjar i analysen.

De variabler vi undersökte för att se vad som bäst predikterade könet var datum, längden av vinge, stjärt och culmen, näbbens bredd och djup, kroppsvikt, första och tredje handpennans längd samt de fem första komponenterna av en principalkomponentanalys av de biometriska variablerna. De olika modellerna för könsbestämning bedömdes med hjälp av Akaikes informationskriterium.

Vi fann att de sex kvalitativa färgkategorierna som vi använt vid de visuella färgbestämningarna i fält visade signifikanta olikheter för färgrenhet och färgton på bröstet och för färgrenhet på ryggen (Tabell 1, Tabell 2).

Av de morfologiska variablerna visade vinglängd, stjärtlängd och längden av tredje handpennan signifikanta skillnader mellan könen (Tabell 3). De fem bästa regressionsmodellerna för könsbestämning ges i Tabell 4. De två modeller som är allra bäst (lägst AIC) inkluderar (1) vinglängd, färg, datum och interaktionen mellan vinglängd och datum respektive (2) vingländ, datum och interaktionen mellan vingländ och datum. Alla övriga AIC-värden är mer än fyra enheter högre än den bästa modellens. Det anses att en skillnad på 2–3 enheter är tillräcklig för att en modell skall vara bättre än en annan. Användningen av vinglängd och datum tillåter könsbestämning av 80,9% av ungfåglarna. Lägger man till dräktens färg ökar andelen bara till 82,9% (Tabell 5).

Vi har således visat att hanar och honor hos gulhämplingens ungfåglar har olika färg. Honor är mera gråbruna medan hanar är mera gulbruna. Hanarna har högre färgmättnad på rygg och bröst och allmänt mera gulaktig färgton. Eftersom användning av enbart vinglängd resulterade i korrekt könsbestämning av 81% av ungfåglarna, anser vi att det i de flesta fall räcker att använda detta enkla mått. Inkluderingen av datum höjde inte procenten rätt könsbestämda fåglar, men datum uppträdde i båda de bästa korrelationsmodellerna. Detta antyder att datum kan vara en betydelsefull variabel, troligen för att hanar som fångats under de allra första dagarna efter utflygningen ännu inte har fullt utvuxna vingpennor. Betydelsen av färgskillnader hos gulhämplingens ungfåglar är, trots statistisk signifikans, av mindre betydelse än hos citronsiskan.