



Sexing juvenile Greenfinches *Carduelis chloris* by the extent of black on the tail

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There is increasing interest in the study of the evolution of sex ratios in birds. Correct assignment of sex to fledgling and juvenile birds is critical for studies that deal with differential sex allocation at nests or sexual variation in survival or dispersion rates. Here we describe a non-intrusive method based on plumage colouration by which juvenile and fully developed nestling greenfinches can be sexed reliably. By measuring the length of the black area on the fifth tail feather rachis, we were able to sex 100% of birds reliably; males had lengths less than 31.44 mm, whereas females were longer. The Greenfinch may, therefore, be a valuable species for the study of sex ratio variation.

There is an increasing interest in the study of sex ratio variation in brood production, and sex differences in survival and migration of juveniles after fledging (reviewed in Sheldon 1998, Lessells & Quinn 1999). It is important for such studies to correctly sex fledgling and juvenile individuals. Laparotomy and genetic methods are available (Harder & Kirkpatrick 1994, Ellegren 1996, Lessells & Mateman 1996), but they are highly intrusive and prohibitively expensive for general use on a very large scale. Many bird species show sexual dimorphism in plumage colour, but the differences between sexes are usually less obvious within juveniles before their first moult (Spencer & Mead 1978). In some species there is a gradient between two extremes, corresponding to easily identifiable males and females respectively, in which some of the juvenile population show an intermediate colour pattern (Svensson 1998). Consequently, these intermediate cases are difficult to sex in the field, and make data sets incomplete.

The Greenfinch *Carduelis chloris* is a 25 g passerine which shows sexual dimorphism for plumage colouration after the first moult, but which has juveniles (EURING code 3J) which are less obviously dimorphic (Svensson 1998). A large proportion of juvenile males show extensive yellow wing and tail patches, similar to adult males, and juvenile females are generally less brightly yellow; there are, however, many juveniles which show an intermediate pattern. The aim of this study was to find a colour trait that reliably enabled us to sex juvenile greenfinches. Since the post juvenile moult in this species is partial, individuals retain outermost wing and tail feathers, whereas they moult body feathers into a

brighter (male) or a duller (female) plumage relative to their sex. We can, therefore, measure yellow wing and tail patches on first-year Greenfinches (EURING codes 3 and 5) which can be readily sexed following Svensson (1998), to assess whether these colour traits reliably indicate sex in juveniles (Mariné & Copete 1994).

METHODS

We trapped Greenfinches using mist nets at baited feeders at three different areas in the middle west of Galicia (northwest Spain), separated by 100 km. We trapped 54 fully moulted first-year Greenfinches between November 2001 and August 2002. The extent of yellow was measured with a calliper (to the nearest 0.05 mm) on the fifth primary, from the distal end of the respective greater covert to the distal end of the yellow area on the primary. Preliminary work with the first 37 birds captured showed the fifth primary to be the best predictor of total wing yellow patch, as the length of the yellow on the fifth primary achieved the highest factor score ($r = 0.96$) in a Principal Component Analysis (PCA) which included lengths of yellow areas on primaries three to 10.

The extent of the yellow tail patch was measured with a calliper (to the nearest 0.05 mm) on the fifth rectrix, as the length of the black area on the rachis. The length of the black area is inversely related to the size of the yellow area, but is easier to measure. The length of the black area on fifth rectrix was the best predictor of the total area of black on the tail, as this measure achieved the highest factor score ($r = 0.99$) in a PCA including black lengths of rectrices four to six.

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Once we obtained these results, and given that both wing and tail measurements were highly correlated ($r = -0.80$, $P < 0.001$, $n = 37$), we simplified methods, and shortened handling time, by measuring only the length of the black area on the fifth rectrix. The measures were highly repeatable (three blind measures of each individual for the first 30 birds, $r = 0.95$).

RESULTS

A discriminant analysis of sex in Greenfinches by the extent of black on the fifth rectrix resulted in a 100% of individuals being correctly classified (Wilks' Lambda: 0.05, $F_{1,83} = 1454.89$, $P < 0.001$; Table 1). The critical length of the black area on the fifth rectrix rachis was 31.44 mm (Fig 1); males had a value shorter than 31.44 mm, females were longer.

Table 1. Summary of the sex discriminant function analysis by the length of the black area on the 5th rectrix rachis in first-year Greenfinches. When using the classification function; males have Y greater than zero, females have Y less than zero.

	Males (n = 34)	Females (n = 20)
Mean length (\pm SD, mm)	17.70 \pm 3.28	44.76 \pm 3.21
95% confidence interval (mm)	16.55 – 18.84	43.26 – 46.26
Classification function	$Y = 80.181 - (2.551 \times \text{black length})$	

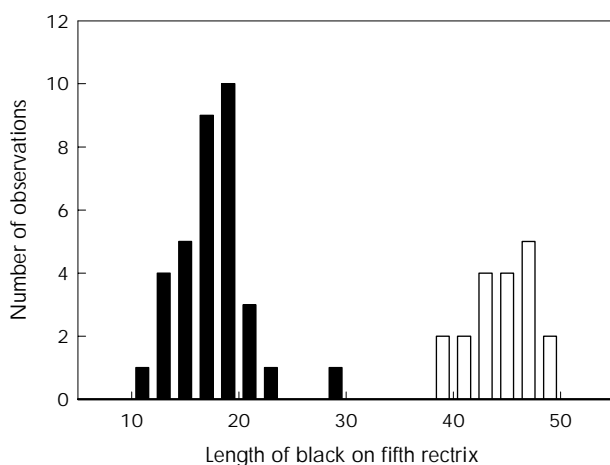


Figure 1. Frequency distribution of black length (mm) on the 5th rectrix rachis of first-year Greenfinches; males (filled bars), females (unfilled bars). Note where the critical value 31.44 mm is situated.

DISCUSSION

Discriminating between the sexes of juvenile birds and fledglings is of great importance to studies that deal with sexual variation in mortality rates, dispersal strategies or primary sex ratios (Ketterson & Nolan 1983, Clutton-Brock 1986, Breitwisch 1989, Gowaty 1993, Weatherhead & Montgomerie 1995, Lessells & Quinn 1999, Julliard 2000). Other sexing methods, such as laparotomy or genetic analysis have been used on other species (Harder & Kirkpatrick 1994, Ellegren 1996, Lessells & Mateman 1996), but are highly intrusive, expensive and not viable for use on very large scales, such as nationwide ringing schemes. Using the opportunity that partial moult gives us, we have found a reliable, quick and cost-free method which is based on plumage characteristics present on juvenile and fledgling Greenfinches. Our data show that, at least in this species, 100% of juveniles may be sexed by plumage colour. Given that we measured individuals from different populations, including individuals captured between November and February which could easily come from Central European populations (Asensio 1986), the findings of our study can be considered as quite conclusive. Additionally, we provide an objective value to improve the sexing of first-year Greenfinches. The species may prove to be of great value for the study of sex ratio variation at nests, and sex differences in survival and migration of juveniles after fledging.

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REFERENCES

- Asensio, B. (1986) La migración en España del verderón común (*Carduelis chloris*, L) según los resultados de anillamiento. *Doñana, Acta Vertebrata* **13**, 103-110.
- Breitwisch, R. (1989) Mortality patterns, sex ratios, and parental investment in monogamous birds. *Current Ornithology* **6**, 1-50.
- Clutton-Brock, T.H. (1986). Sex ratio variation in birds. *Ibis* **128**, 317-329.

- Ellegren, H.** (1996) First gene on the avian W chromosome (CHD) provides a tag for universal sexing of non-ratite birds. *Proceedings of the Royal Society of London. Series B* **263**, 1635-1641.
- Gowaty, P.A.** (1993) Differential dispersal, local resource competition, and sex ratio variation in birds. *American Naturalist* **141**, 263-280.
- Harder, J.D. & Kirkpatrick, R.L.** (1994) Physiological methods in wildlife research. In *Research and management techniques for wildlife and habitats* (ed Bookhout, T.A.) pp 275-306. The Wildlife Society, Bethesda, Maryland.
- Julliard, R.** (2000) Sex-specific dispersal in spatially varying environments leads to habitat-dependent evolutionarily stable offspring sex ratios. *Behavioral Ecology* **11**, 421-428.
- Ketterson, E.D. & Nolan, V.** (1983). The evolution of differential bird migration. *Current Ornithology* **1**, 357-402.
- Lessells, C.M. & Mateman, C.** (1996) Avian genetics. Molecular sexing of birds. *Nature* **383**, 761-762.
- Lessells, C.M. & Quinn, J.S.** (1999) Primary sex ratios: Variation, Causes and Consequences. In *Proceedings of the 22nd International Ornithological Congress* (eds Adams, N.J. & Slotow, R.H.) pp 422-424. BirdLife South Africa, Durban & Johannesburg.
- Mariné, R. & Copete, J.L.** (1994) Sexing juvenile Siskins *Carduelis spinus*. *Butlletí del Grup Català d'Anellament* **11**, 7-9.
- Sheldon, B.C.** (1998). Recent studies of avian sex ratios. *Heredity* **80**, 397-402.
- Spencer, R. & Mead, C.J.** (1978). Hints on ageing and sexing throughout the year. *Ringers' Bulletin* **5**, 55-56.
- Svensson, L.** (1998) *Guía para la Identificación de los Passeriformes Europeos*. Sociedad Española de Ornitología. SEO/BirdLife, Madrid.
- Weatherhead, P.J. & Montgomerie, R.** (1995). Local resource competition and sex ratio variation in birds. *Journal of Avian Biology* **26**, 168-171.

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