Sex and age determination in nestling Goshawks *Accipiter gentilis*

S. MAÑOSA

A method for sexing and ageing nestling Goshawks is presented. A discriminant function using body mass and the length of the seventh primary, culmen and tarsus lengths allowed sex determination from the age of 15 days, with an accuracy of 94.4%. Age in the first two weeks of life was best determined by tarsus length. After 15 days old, the length of the seventh primary can be used to estimate age to within two days.

Key words: Goshawk, *Accipiter gentilis*, growth, sex and age determination, Catalonia, Spain.

Santi Mañosa. Departament de Biologia Animal, Universitat de Barcelona, Avda. Diagonal 645, 08028, Barcelona.
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INTRODUCTION

The Goshawk *Accipiter gentilis* is a common bird of prey in some areas of Catalonia (Mañosa 1994). A large number of studies have been carried out on the biology and ecology of this species, and it has been used to monitor environmental change (Ellenberg & Dietrich 1981). Provided the appropriate materials and data are collected, a good deal of information can be obtained during single ringing visits, allowing the optimization of the research effort and a reduction in the amount of disturbance caused.

The Goshawk shows extreme reversed sexual size dimorphism (Baker 1993). Several papers provide information on ageing and sexing nestlings of northern populations (Wikman 1976, Kenward et al. 1993), but, taking into account the strong clinal size variation of this species over its geographical range (Wattel 1973), these methods might not be useful in southern areas, where Goshawks are considerably smaller. The objective of this paper is to describe methods of ageing and sexing nestling Goshawks before they have reached full size, on the basis of morphological measurements, in the southern parts of the species' range. This would facilitate accurate phenology studies and the estimation of the nestling sex ratio, both of which are crucial for the study and management of such a dimorphic bird of prey.

STUDY AREA AND METHODS

Altogether, eighty-two nestling Goshawks (40 males and 42 females) from

32 nests were measured in the period 1987-1989 in the county of La Segarra, in central Catalonia, NE Spain (Mañosa 1994). Chicks were measured every fourth or fifth day from hatching to fledging, a period covering 35-45 days (Mañosa 1991). Hatching date was known to within one day as a result of the regular inspection of the nests every two days around the expected hatching date (estimated from the laying date), and every chick was colour-marked with a felt-tip waterproof pen as soon as it was found. Body mass was measured, by means of a spring balance, to the nearest gram; tarsus length, from the back of the tarsal joint to the base of the central toe, and culmen (= bill length), from bill tip to the distal edge of the cere, were measured with a digital caliper to the nearest 0.01 mm. Culmen length was not measured in 1987. The length of the seventh primary (the fourth outermost) and the central tail feather were measured, using a metal ruler, to the nearest 1 mm from the tip of the feather to the skin insertion point.

In the Goshawk, both sexes show identical size at hatching (Mañosa 1991), but sexual size dimorphism develops quickly during the nestling period, females being considerably larger than males after growth has been completed (Baker 1993), making sex determination easy just prior to fledging. To ensure that no chicks incorrectly sexed were included in the analyses, only chicks surviving to 30 days were used. One nestling showing extremely deficient growth (reduced mass gain rate and subsequent death) was also excluded.

In order to establish a method for sex determination, body mass, tarsus length and culmen length were plotted against seventh primary length, excluding points with zero value for the latter variable. To establish a method for age estimation before 15 days of life, age was plotted against the $\log_{10}$ of tarsus length. After feather emergence, age was plotted against seventh primary length and tail length. Regression lines were fitted using feather length or the $\log_{10}$ of tarsus length in millimetres as independent variables and age in days as a dependent variable. A stepwise discriminant analysis using only measurements for chicks over 15 days old was conducted in order to establish an objective and accurate method for sexing nestlings older than this age. Statistical analyses followed Zar (1984) and were performed with the SPSS/PC package. Default values of this package were used in the discriminant analysis, using Wilk's lambda as a criterion to enter variables. Nest visits were conducted with permission of the Departament d'Agricultura, Ramaderia i Pesca de la Generalitat de Catalunya.

RESULTS

Male and female nestling Goshawks showed separate distributions of tarsus length, culmen length and body mass in relation to seventh primary length, which allowed graphical discrimination between sexes after the second week of life (Fig.1). Following the results plotted therein, the discriminant analysis was only conducted for nestlings older than 15 days (Table 1). The functions thus obtained correctly classified 94.4 % of the cases after 15 days and 97.5 % of the cases after 20 days. Discriminant functions for chicks before that age performed very poorly, as expected from figure 1, so it was not possible to give a valid criterion to sex Goshawks before that age.

Chick age was found to be linearly related to seventh primary length (AGE = 0.159 x PRIMARY + 10.129; $r^2 = 0.974$; SE of estimate = 1.41; N = 636; Fig. 2), but analysis of covariance (ANCOVA)

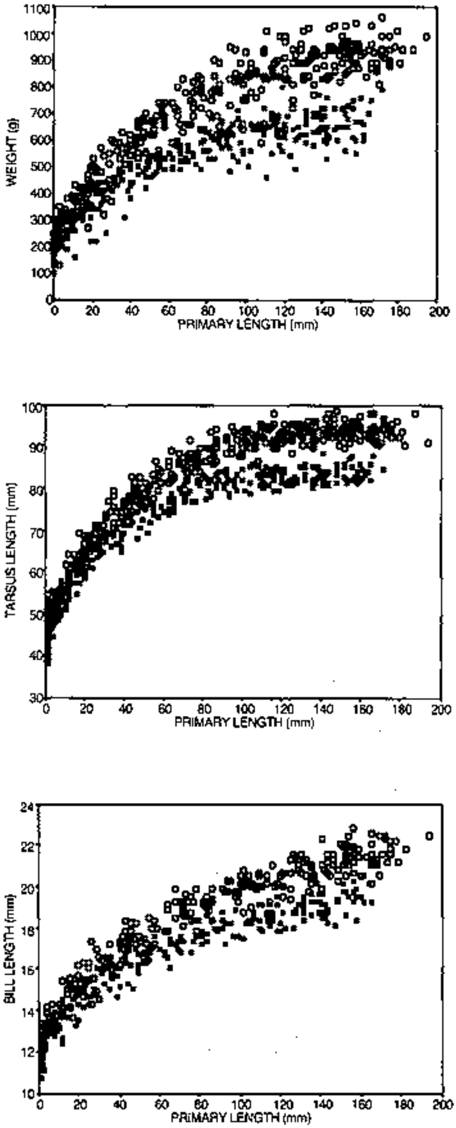

Figure 1. Weight, tarsus length and bill length for male (■) and female (□) nestling Goshawks in relation to the seventh primary length.

Figura 1. Pes, longitud del tars i longitud del bec dels polls d'Astor mascles (■) i femelles (□) en relació a la longitud de la setena

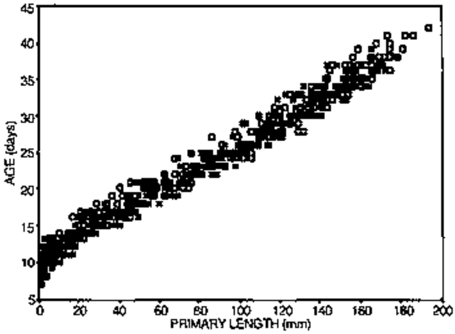

Figure 2. Relationship between age and seventh primary length for male (*) and female (□) nestling Goshawks.

Figura 2. Relació entre l'edat i la longitud de la setena primària per als polls d'Astor mascles (*) i femelles (□).

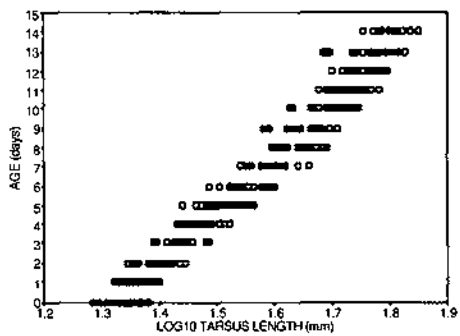

Figure 3. Relationship between age and tarsus length for Goshawk chicks less than 15 days old.

Figura 3. Relació entre l'edat i la longitud del tars per als polls d'Astor de menys de 15 dies d'edat.

showed significant differences between the regression lines fitted to males and females ($F = 10.41$; $P < 0.001$). Accordingly, independent linear regression

	Standardized coefficients	Function coefficients Male N=151	Female N=204
PRIMARY LENGTH (mm)	–1.8628	–0.9918252	–1.112262
BODY MASS (g)	1.15714	–0.2309577	–0.206299
CULMEN (mm)	0.85596	28.70254	30.13544
TARSUS LENGTH (mm)	0.20226	4.798304	4.883738
CONSTANT	—	–333.9371	–372.5778
Percent correct	—	96.7%	92.6%

Table 1. Results of the discriminant analysis and discriminant functions for sex determination. Discriminant scores for a given case are calculated using the function coefficients and constants for male and female respectively. The case is then assigned to the group giving the largest discriminant score. Sample size: male, n = 151; female, n= 204.

Taula 1. Resultats de l'anàlisi discriminant i funcions discriminants per a la determinació del sexe. Per a cada cas concret que es vol classificar es calculen dos valors discriminants, utilitzant els coeficients de les funcions discriminants i les constants corresponents a mascles i femelles respectivament. Llavors, el cas s'assigna al grup que dóna el valor discriminant més alt. Mostra: mascles, n = 151; femelles, n = 204.

models were developed for males (AGE_m = 0.161 x PRIMARY + 9.776; r^2 = 0.973; SE of estimate = 1.39; N = 291) and females (AGE_f = 0.158 x PRIMARY + 10.436; r^2 = 0.976; SE of estimate = 1.41; N = 345). The 95% confidence intervals for individual estimates obtained by these equations amounted to about ± 2.8 days. Models using tail length performed slightly less efficiently (AGE = 0.173 x TAIL + 11.709; r^2 = 0.958; SE of estimate = 1.80; N = 636; AGE_m = 0.177 x TAIL + 11.228; r^2 = 0.960; SE of estimate = 1.68; N = 291; AGE_f = 0.171 x TAIL + 12.116; r^2 = 0.958; SE of estimate = 1.86; N = 345). Before chicks were 15 days old, they were best aged by means of tarsus length (AGE = 27.547 x LOG_{10}TARS - 36.579; r^2 = 0.963; SE of estimate = 0.88; N = 363; Figure 3). The 95% confidence intervals for individual estimates were about ± 1.7 days. No difference was found between male and female chicks (F = 0.07; *P* = 0.791).

DISCUSSION

After the seventh primary feather has attained a length of 60 mm (around the age of 20 days), the sex of nestling Goshawks can be determined graphically by means of single measurements of body mass, tarsus length or culmen length combined with seventh primary length. However, some chicks can be confidently sexed graphically as early as at 15 days old (seventh primary length around 30 mm), especially in mixed broods, and the use of the discriminant functions allows correct sex determination for most of them at this early age. Although body mass is a highly dimorphic variable, it depends largely on the birds' general condition and suffers daily variation, so caution must be taken when using this variable alone as a sex predictor (see Fig. 1). This may also explain why more female than male cases were misclassified by the discriminant functions (Table 1), since an underweighed female may result in a male score, given the relatively large standardized coefficient for the body mass variable. Because of the clinal variation in Goshawk size, caution must also be taken when applying this method to individuals from areas other than the present study area, and only if assymptotic body mass and tarsus length fall within the values shown here would the equations and graphs provided be useful. Culmen and tarsus length both show a large degree of sexual dimorphism but, according to Bortolotti (1984), the former must preferably be used because of its higher repeatability. Tarsus diameter, foot length, claw length and bill depth (not measured here) have been shown to be highly dimorphic and repeatable (Bortolotti 1984), so they could be investigated in the future in relation to sex discrimination, as they may permit closer precision and thus sex determination at an earlier age.

Primary length can be measured easily and accurately (Bortolotti 1984), and feather growth shows little variation even when food is in short supply (O'Connor 1984, Picozzi 1980, Moss 1979, Donázar & Ceballos 1989, Hiraldo et al. 1990, Veiga & Hiraldo 1990, Olsen et al. 1982). Although there are sexual differences in the rate of feather growth, the difference between the age estimates obtained using the general or the sex-specific equations never exceeds 0.7 days, and decreases with age. As found in other studies too (Poole 1989, Sodhi 1992), sexual dimorphism in this respect is small, so the equations relating primary length and age can be confidently used to estimate nestling age to within two days, even when information on nestling sex is lacking. In the regression analyses, the assumption of independence of the data points was partially violated, as the data corresponded to repeated measurements of a series of individuals. As a consequence of that, the standard errors and confidence intervals of the estimates may have been underestimated, but the large number of nestlings measured may have counteracted this effect.•

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RESUM

Determinació del sexe i de l'edat dels polls d'Astor *Accipiter gentilis*

Es presenten mètodes per determinar el sexe i l'edat dels polls d'Astor Accipiter gentilis *abans d'abandonar el niu. Els polls d'Astor poden ser sexats a partir dels 15-20 dies d'edat en base al pes, la longitud del tars i la longitud del culmen en relació a la longitud de la setena primària, i també fent servir una funció discriminant. L'edat dels polls abans dels 15 dies es pot determinar per mitjà de l'equació EDAT = 27.547 x LOG_{10} LONGITUD TARS – 36.579 i, després d'aquesta edat, amb l'equació EDAT = 0.159 x LONGITUD PRIMARIA + 10.129 si no es coneix el sexe del poll o, si es coneix, amb l'equació $EDAT_m$ = 0.161 x LONGITUD PRIMARIA + 9.776 per als mascles i $EDAT_f$ = 0.158 x PRIMARIA + 10.436 per a les femelles.*

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