SHORT COMMUNICATIONS

Successive removal of individual rectrices does not influence the subsequent growth of the replacement feathers in the Great Tit *Parus major*

Ptilochronology is the study of feather growth rates as revealed by the width of daily growth bars. Growth bars are cross-bands on feathers that denote 24-h periods of growth. The method consists of plucking a rectrix from a bird that is then released and, on recapture a month or more later, measuring the width of the growth bars on the replacement rectrix. This field technique has been suggested as a means of assessing the nutritional status of free-ranging birds and is increasingly being used (see Harder & Kirkpatrick 1994, Grubb 1995 for reviews).

When birds are monitored over a long period, successive feathers may be taken from the same follicle so that daily growth bar widths can be compared between different stages of the biological cycle (Grubb & Pravosudov 1994, Grubb 1995). A study of this kind relies on the assumption that recent follicle history has no effect on feather growth rate (i.e. there is no physiological constriction: Murphy 1992, Grubb & Pravosudov 1994). Grubb and Pravosudov (1994) addressed this problem, suggesting that follicle history does not affect feather growth rates. However, their study did not test the effect of successive removal of feathers between the sexes, or by age and body condition, all of which have already been shown to affect feather growth rates (Grubb & Cimprich 1990, Grubb *et al.* 1991, White *et al.* 1991, Nilsson *et al.* 1992, Grubb 1995). Additionally, their study was carried out on captive House Sparrows *Passer domesticus*, so we do not know whether the results are applicable to birds in the wild.

The aim of this study was to test whether successive removal of individual rectrices influences the subsequent growth of the replacement feathers in free-ranging Great Tits *Parus major*, taking into account the sex, age and body condition (pectoral muscle width) of the birds.

MATERIAL AND METHODS

Field work was carried out from November to March, during the winters of 1994–1995 and 1995–1996 in a suburban area of Barcelona, northeastern Spain. Great Tits were caught in funnel-traps baited with husked peanuts. Birds were ringed for individual recognition with aluminium rings. For each bird, we determined body mass to the nearest 0.01 g with an electronic balance and pectoral muscle width with an ultrasonic device (Krautkrämer USK 7 S; Newton 1993). We also plucked the right and left fifth tail feathers (R5, L5). Because the extraction of the outermost pair of the 12 rectrices could affect the manoeuvrability of birds while flying, we selected the second outermost rectrices. The moult of adult Great Tits is spread from June to September and is complete. Nearly all the juveniles also moult rectrices during this period (Gosler 1993, Jenni & Winkler 1994). Therefore, all the birds had completed moult of tail feathers before the sampling periods.

Average growth bar width was calculated for the first ten growth bars clearly visible from the distal part on each feather. Rectrices were fixed to a piece of porexspan by inserting two entomological pins through the feather to mark the distal and the proximal ends of ten growth bars. The distance between the two marks was then measured to the nearest 0.01 mm. This value was divided by ten to give an estimate of the mean rate of feather growth per day. Induced feather growth rate was estimated as the average of left and right feather growth rates.

During the first fortnight of November, we trapped 32 Great Tits (15 in 1994–1995, 17 in 1995–1996) which were later recaptured within the same winter during the first half of January and again during the first half of March. At each capture, tail feathers R5 and L5 were removed. As a consequence, we obtained for these birds two induced feathers. Seventeen birds (seven in 1994–1995, ten in 1995–1996) were first captured during January and recaptured in March. Only one induced feather was obtained for these birds.

The effect on follicle history was studied by means of an unsaturated four-way ANCOVA, where average pectoral muscle width during the study period was used as a covariate. Because our goal was to study the effect of previous feather removal on feather growth rate, we controlled for the effects of other factors (between-years differences, sex and age of Great Tits), and we checked if the effect of follicle history changed with different levels of the other factors, using the interaction terms treatment × year and treatment × sex × age (type III sum of squares model). By using only two interaction terms, instead 11 interaction terms of a fully saturated ANOVA model, we avoided the problem inherent to a complex factorial design with multiple comparisons (i.e. multiple estimations of probabilities) and multiple *F*-tests that are correlated because they are based on a common denominator (mean square error; Wilkinson 1990). Before analysing the data using this unsaturated model (four pure effects and two interaction terms), we checked the assumption of homogeneity of slopes of ANCOVA models.

Table 1. *February–March mean growth bar widths according to year and treatment group (one feather removed [n = 32 birds, 15 in 1995, 17 in 1996] or two feathers removed [n = 17 birds, seven in 1995, ten in 1996])*

	Growth bar width (mm; mean ± s.e)
Year	
1995	2.25 ± 0.026
1996	2.42 ± 0.027
Treatment	
Removed once	2.35 ± 0.030
Removed twice	2.34 ± 0.034

Table 2. *Four-way unsaturated* ANCOVA *of the effect of year, sex, age and feather-plucking treatment (feather removed once or twice) on the width of growth bars of induced feathers (width of pectoral muscle included as covariate)*

	$F_{1,41}$	P
Treatment	0.02	n.s.
Year	7.68	<0.01
Sex	1.29	n.s.
Age	0.24	n.s.
Treatment × year	1.04	n.s.
Treatment × sex × age	2.82	n.s.

RESULTS AND DISCUSSION

Growth rates of March induced feathers were greater in 1996 than in 1995 (Tables 1 and 2). However, the taking of one or two feathers (treatment) did not affect growth rates. This was consistent between years, sexes and ages (i.e. no interactions; Tables 1 and 2).

The result also held when we took into account the width of the pectoral muscle, which had been suggested to affect the speed of moult (Gosler 1991). In the present study, however, width of the pectoral muscle did not have a significant effect on growth rates ($F_{1,41}$ = 3.93, n.s.; parallelism test, interaction between treatment, sex, age and muscle width: $F_{1,39}$ = 0.86, n.s.; interaction between treatment, year and muscle width: $F_{1,39}$ = 2.17, n.s.).

The results support the assumption that induced rectrices in Great Tits grew independently of the recent history of the follicle and validate the use of ptilochronology as a valuable technique to compare body condition at different time periods.

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A Mediterranean breeding colony of Cory's Shearwater *Calonectris diomedea* in which individuals show behavioural and biometric characters of the Atlantic subspecies

The breeding distribution of the Cory's Shearwater *Calonectris diomedea* covers the Mediterranean, Macaronesia and the Cape Verde Islands (Cramp & Simmons 1977). Three subspecies are currently recognized because of their morphology (Bourne 1955, Bannerman & Bannerman 1968, Granadeiro 1993) and vocalizations (Hazevoet 1994, 1995 and pers. obs.). Birds from Cape Verde (*C. d. edwardsii*) occupy a position distinct from Atlantic (*C. d. borealis*) and Mediterranean birds (*C. d. diomedea*). Although there is a clinal increase in body size from the east (Mediterranean) to the west (Atlantic; Massa & Lo Valvo 1986, Granadeiro 1993), genetic differences between birds in two Mediterranean colonies on the one hand and an Atlantic breeding group on the other were found to be of the same order as generally found between subspecies (Randi *et al.* 1989, Wink *et al.* 1993). Moreover, there was a marked difference between the Mediterranean and Atlantic subspecies in the structure of the duet call (Bretagnolle & Lequette 1990) and in their wintering distributions (Mougin *et al.* 1988).

There are two reported cases of possible exchange between the Atlantic and Mediterranean populations (Lo Valvo & Massa 1988, De Juana 1994); a fledgling female ringed on Selvagem Grande Island was found 9 years later in a nonbreeding condition on Linosa (Sicilian Channel), and a fledgling male ringed at the same locality was found 10 years later on Colombretes Island (Spain), again nonbreeding. Another fledgling female from Selvagem Is-