Adult biometrics and nestling growth in a southern Prealpine Dipper *Cinclus cinclus* population

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Abstract - Biometrics of adult and nestling Dippers were studied along a 12.5 km stretch of the River Posina (Vicenza Prealps, northeastern Italy) during 1991-1996. Results were compared with other European data. Biometrics were collected from ca. 250 birds, mist-netted all year round. Independently of age, Dippers were classified as males or females if their wing length was above or below 91.0 mm, respectively. Body mass reached the maximum value during moult (August) and the minimum one at the end of breeding season (June). Growth rate of nestling Dippers ($k = 0.350$) did not differ from that observed in the Swiss Alps.

Introduction

The Dipper *Cinclus cinclus* occurs along the upper reaches of streams and rivers throughout much of Europe with a number of geographical races, but intensive studies have been carried out only in northern and central parts of the continent (Tyler and Ormerod 1994). Knowledge about the Dipper populations breeding in the south of the range, particularly regarding biometrics and nesting ecology, is very limited. As part of a long-term study on the Dipper ecology, conducted along the River Posina in the Vicenza Prealps during 1991-96, this paper describes and attempts to explain variations in wing length and seasonal changes in body weight of adult birds. We also provide preliminary data on growth of nestlings up to the fledging age and compare our results with those published from other European areas.

Study area

The River Posina rises at Passo della Borcola (1050 m above sea level) and joins the River Astico south of the town of Arsiero (255 m, 45° 48' N, 11° 21' E), in the Vicenza province, NE Italy (Fig. 1). The Posina catchment covers a total of 45.3 km². The substrate is mainly composed by Mesozoic limestone, what explain the base-rich waters of the river (mean hardness = 15.35 French degrees, mg $CaCo_3 l^{-1}$, mean pH = 8.2). The monthly mean discharge ranges between 2.5 and 7.5 m³/sec. On the basis of the zonation of Illies and Botosaneanu 1963 (in Ghetti 1986), R. Posina belongs for the most part to metarhithron (current speed about 35 cm/sec). Engineering operations were locally performed since the late '60 with dams, weirs and large blocks of limestone or bituminous layering on the banks preventing flood damages, and with hydroelectric schemes or wells for water uses.

It is possible to subdivide the R. Posina into two portions: the upper with a bed lesser than 1 m wide and without a continuous downflow, the second one with suitable physiographic characteristics for Dippers. The research was carried out in this main part of the stream, from Contrada Beber (600 m above sea level) 12.5 km downstream to Stancari (400 m), including the favourable terminal tracts of the Posina tributaries.

Methods

Biometrics

Birds were trapped in mist-nets set across the stream. During the breeding season the nets were placed very close to each nest in order to assess the identity of territory owners. To reduce the risk of nest desertion by female, captures were carried out after the end of egg-laying. Outside the breeding season, weekly capture sessions took place in subsequent segments of the river, covering each year the entire study area. Each bird was individually identified by ring number, sexed according to the presence/absence of brood-
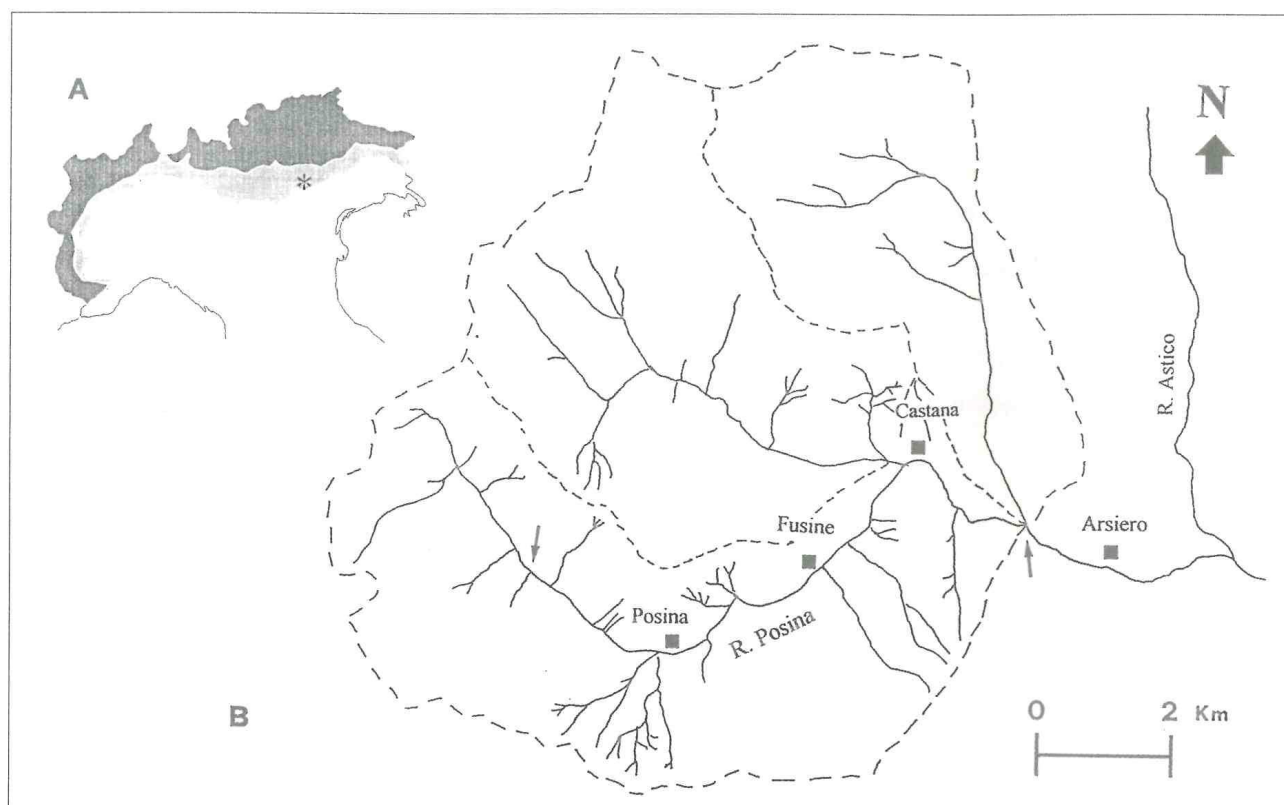
Figure 1. (A) Italian Alps (dark grey) and Prealps (light grey). (B) Map of the study area. The boundaries of the catchment (broken line) and sub-catchment (dashed lines) basins of River Posina are shown. Arrows delimit the investigated part of the stream.

patch or to the wing-length discriminant modified for the studied population. Ageing was based on plumage and iris features (Svensson 1984). Wing length was measured to the nearest 0.5 mm with a stopped ruler, using the maximum chord method (Svensson 1984). Body mass was recorded to the nearest 0.1g using Pesola spring balances. To avoid inter-observer variability, both sets of measurements were always taken by one of us (ST).

Nestling growth

Dipper broods were weighed 1-5 times, from hatching (= day 1) and for a large part of the nestling period; weights were not taken after the 17th day to avoid nest desertion. Chicks were weighed with a 50 or 100 g Pesola spring balance with an accuracy of ± 0.1 g. To assess the pattern of chick growth two different samples were used. In the first sample nestling age was exactly known, by checking the clutch at hatching (eggs and chicks present); the second sample included also nestlings whose age was estimated from the first egg date of laying (for incubation length see below). Hatching is usually considered to be synchronous (Cramp 1988), although there are instances of the last egg hatching with one-day delay (Breitenmoser-Würsten 1997). Because of differ-

ences in nestling weight during growth between successive breeding attempts (Breitenmoser-Würsten 1997; pers. obs.), only first broods were taken into account. Although sexual dimorphism in size began to appear during growth, sexing every chick was not possible and, consequently, a separate analysis was not performed (Ormerod et al. 1986).

In the first sample, weight data of nestlings were fitted to a logistic equation of the form:

$$W_{(t)} = A/1 + exp(-k(t - t_{50}))$$

where $W_{(t)}$ is the body mass (g) at age t (days since hatching), A is the asymptotic mass (g), k is the growth rate (g day^{-1}) and t_{50} is the age at the inflection point of the growth curve (days), which is the age at which half of the growth is completed. A, k and t_{50} were estimated from the weight data fitting them to a non-linear regression model (Ricklefs 1967).

In the second sample, we estimated the k parameter by linear regression between 4 and 13 days, when chicks growth was nearly linear (Ormerod et al. 1986; O'Halloran et al. 1992).

The statistical analysis was performed with the STATISTICA package (StatSoft 1995).

It was not possible to gather enough data on all vari-

ables and this accounts for differences of sample sizes between analyses.

Results

Biometrics

Wing length ranged in males from 91.0 to 99.0 mm (mean ± sd = 95.1 ± 1.73, n = 107) and in females from 83.5 to 91.0 mm (87.4 ± 1.68, n = 97). Overlap between sexes was very narrow, falling only on 91 mm (Fig. 2). Therefore, Dippers were classed as males if their wing length was ≥ 92.0 mm and as females if their wing length was ≤ 90.0 mm.

Measurements of 85 male and 84 female Dippers, whose age ranged between 1 and 4 years, enabled us to examine the variation of wing length according to age (Table 1). Despite scanty data in older age classes, an indication of increasing wing length with age was apparent exclusively in males (ANOVA ♂ $F_{3,81}$ = 4.67, p = 0.005; ♀ $F_{3,80}$ = 0.23, n. s.). This observation was confirmed by comparisons between first-year and adult birds, showing a significant increase in males (t_{105} = − 2.19, p = 0.03) but not in females (t_{95} = 0.48, n. s.). As a consequence, the relative sexual dimorphism (male mean wing length − female mean wing length) increased continuously with age.

According to body size dimorphism, female Dippers were lighter than males, but seasonal mean weight variations kept parallel through the year (Fig. 3). In both sexes, adult weights reached a minimum value in June at the end of the breeding cycle, increased during moult with a peak in August, thereafter sharply declined until December and then showed an increase in winter months. From September to November, there were no significant differences between age groups, but first-year birds weighted significantly
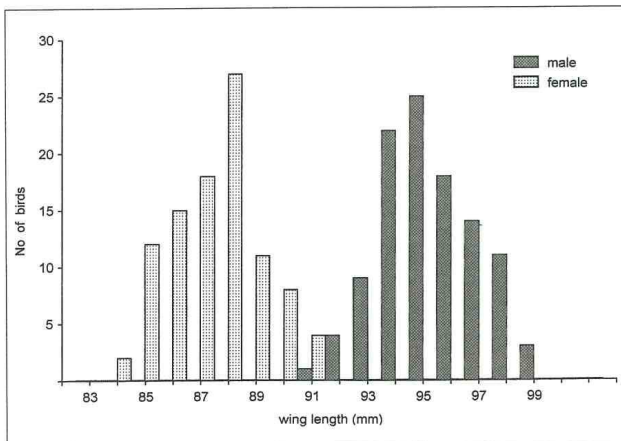
Table 1. Wing length measurements (in mm) for each age and sex class of Posina Dipper. Age class >1 also includes adult birds whose age was not exactly known. RSD=relative sexual dimorphism.

	age	mean	sd	n	RSD
Males					
	1	94.8	1.60	66	7.4
	2	95.1	1.46	11	8.0
	3	97.0	1.77	5	9.5
	4	97.2	1.44	3	10.2
	>1	95.6	1.84	41	8.3
Females					
	1	87.4	1.69	61	
	2	87.1	1.34	15	
	3	87.5	1.00	6	
	4	87.0	0	2	
	>1	87.3	1.67	36	

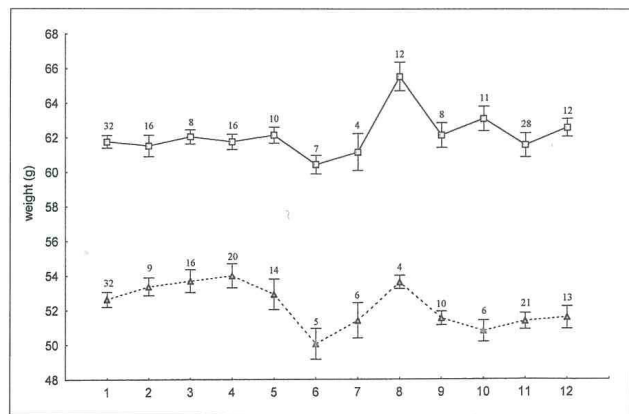

Figure 3. Monthly weight changes of male (□ n = 164) and female (△ n = 156) adult Dippers in River Posina. Means ± se, headed by sample sizes, are given.

lesser than adult ones in December (mean ± sd ♂ = 60.1 ± 2.47 g, 62.5 ± 2.55 g, t = -2.43, df = 25, p = 0.02; ♀ = 49.2 ± 2.33 g, 51.6 ± 3.21 g, t = -2.32, df = 29, p = 0.03).

Nestling growth

Nestlings grew slowly until about the 4th day, afterwards they grew almost linearly up to the 12th day, when they reached ca. 80% of asymptotic weight (Fig. 4). The estimated asymptote (58.04 g) was very close to adult mass represented by the mean value of monthly means (57.4 g; n = 327).

The average growth of nestlings from first clutches only followed the logistic regression equation:

$$W_{(t)} = 58.04/1 + e^{-0.350 (t-8.36)}$$

In comparison with first broods (n = 59), second ones (n = 27) showed smaller values of the growth rate (k = 0.315 g day^{-1}).

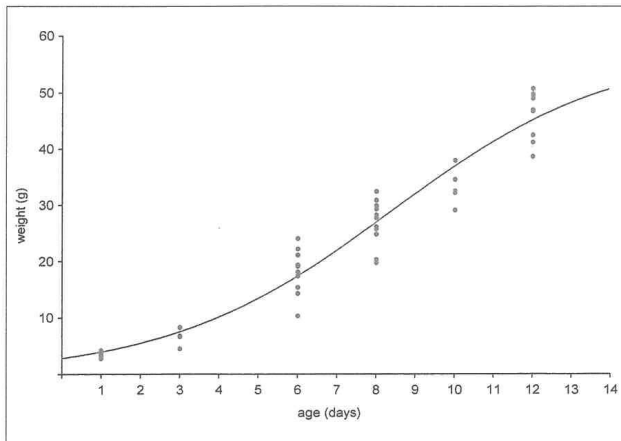Figure 2. Frequency distribution of male and female Dipper wing lengths in River Posina.

Figure 4. Growth curve of nestling Posina Dippers. Data from 59 individual weights were fitted to a logistic equation ($r^2 = 0.95$).

In the extended sample (n = 163) the growth rate calculated by linear regression between 4 and 13 days reached higher values ($k = 0.417$ g day^{-1}).

Out of 399 ringed and weighed nestlings, 37 were recaptured after 30 or more days from fledging, when sexing on wing-length had become possible. The frequency distribution of the standardized weigths, recorded when these birds were 8-15 days old, showed that sexual dimorphism had begun to appear already (Fig. 5), as stated by Ormerod *et al.* (1986). Though it was not possible to sex inequivocally every nestling, 76% of males had a standardized weight > 0, whilst 81% of females had a standardized weight < 0. In particular, at 11-13 days sexes differed significantly in body mass (standardized median weight of male = 0.73 n = 13, standardized median weight of female = – 0.41 n = 14, Mann-Whitney U-test, p = 0.004).
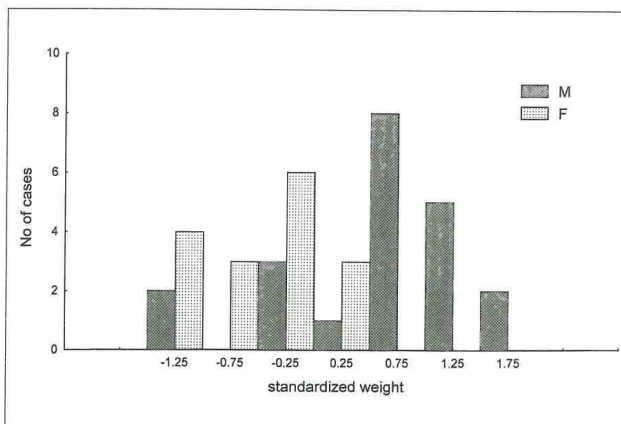

Figure 5. Frequency distribution of weights of 37 Dipper nestlings, later retrapped and sexed (21 males, 16 females). To allow comparisons amongst chicks from broods of different age and size, data were standardized within broods.

Discussion

Biometrics

As reported from the whole breeding range, Dippers in our study area exhibited a clear sexual size dimorphism, with a very narrow overlap in wing length. Excluding the larger Fennoscandian populations of the nominate race, characterized by extensive post-breeding movements, the largely sedentary subspecies *aquaticus* do not show a clinal increase in wing length from south to north (Table 2). However, measurements taken by different methods could affect comparisons between different geographical area. Schmid and Spitznagel (1985) observed a decrease in relative sexual differences (RSD) towards the north in German populations. On the contrary, data from a greater population sample (Table 2) suggest that Dippers breeding in southern latitudes have a less pronounced size dimorphism. Probably, other factors besides latitude are involved in determining variations in the extent of sexual dimorphism among different populations of the Dipper. It has been suggested that genetic isolation and territory quality (Ormerod *et al.* 1986) or insularity (O'Halloran *et al.* 1992) might account for differences in these biometrical parameters in British populations (*C. c. gularis* and *C. c. hibernicus*). The existence of different sex-related selective pressures within a population was assumed by Schmid and Spitznagel (1985) from the frequency distribution and age-related variations of wing lengths. The frequency distributions were skewed to left in adult females and to the right in adult males; moreover, first-year males had significantly shorter wings than older males, whereas first-year females had slightly longer wings than older ones. Moreover, the long-term studies by Marzolin (1990) suggested a progressive increase in body size dimorphism with age. In male Dippers, this author observed an individual increase in wing length with age and a higher survival probability in larger birds; conversely, wing length and survival of females decreased in older birds and in larger ones, respectively. Our results closely fit this evidence, showing a similar variation in wing length related to age (Table 1) and to differential survival in sexes, as the male right-skewed and the female left-skewed distributions suggested (Fig. 2). The pattern of seasonal changes in weight was similar to that recorded in other populations of *C. c. aquaticus* (Görner 1981 in Bub 1984; Marzolin 1990) and in *C. c. gularis* (Galbraith and Broadley 1980; Ormerod *et al.* 1986; Bryant and Tatner 1988). In all these studies females markedly gained weight in winter, prior to the breeding season, whereas males did not exhibit a one-way variation. Thereafter, both sexes reached

Table 2. Wing length (mm) of *Cinclus c. aquaticus* taken from literature and ordered from north to south. RSD (relative sexual dimorphism) = male mean wing length - female mean wing length.

mean	±sd	range	n	RSD	location	reference
Male						
94.3		90-101	80	7.5	Thuringia	Görner 1981 in Bub 1984
95.8	2.54	91-102	52	8.0	Rhineland	Mönig in Bub 1984
95.9	1.73		225	8.1	Lorraine	Marzolin 1990
95.1		89-101	173	8.1	Baden-Württemberg	Rockenbauch 1985
94.7	1.93	90-99	91	7.9	Baden-W. & Bavaria	Schmid & Spitznagel 1985
96.2	1.87		79	8.1	Upper Austria	Priemetzhofer & Pr. 1984
93.2		90-99	89	7.6	Hungary	Horváth 1992
95.1	2.1	91-100	41	7.2	Switzerland	Sutter in Glutz & Bauer 1985
95.1	*1.73*	*91-99*	*107*	*7.7*	*Venetia*	*present study*
Female						
86.8		84-89	71		Thuringia	Görner 1981 in Bub 1984
87.8	1.63	85-93	56		Rhineland	Mönig in Bub 1984
87.8	1.77		243		Lorraine	Marzolin 1990
87.0		83-90	152		Baden-Württemberg	Rockenbauch 1985
86.8	2.25	80-92	69		Baden-W. & Bavaria	Schmid & Spitznagel 1985
88.1	1.54		54		Upper Austria	Priemetzhofer & Pr. 1984
85.6		80-90	107		Hungary	Horváth 1992
87.9	1.5	86-91	21		Switzerland	Sutter in Glutz & Bauer 1985
87.4	*1.68*	*83-91*	*97*		*Venetia*	*present study*

their lowest values at the end of the nesting period, increased their body mass during moult and showed an autumn weight loss. The seasonal changes of body mass was partly in accordance with the annual cycle of the energy expenditure recorded in a Scottish population: energy costs were highest during breeding and lowest during moult (Bryant and Tatner 1988). In our study area, the autumn weight decrease was possibly linked to resuming territorial activities by adults; moreover, the exclusion of first-year birds from high quality territories could explain the low weights reached by this age class in December.

Nestling growth

Postnatal growth is influenced in natural populations by several variables, such as season, geographical area and brood-size (Ricklefs 1983). Despite small sample size, our data suggest a decrease in growth rate in the second part of the breeding season. A higher daily growth rate in nestlings from earlier clutches is also reported by Tyler and Ormerod (1994), whilst Breitenmoser-Würsten (1997) did not find any significant effect of date on development, though an higher k mean in second broods was apparent. The observed decrease in the growth rate of second broods in the R. Posina, could be related to weaker time constraints in the late breeding season. By considering that, on average, 53 days (5 days for egg laying + 16 for incubation + 32 for rearing, Glutz and Bauer 1985) were necessary to complete a successful breeding attempt, in the Posina population ca. 2 days elapsed between the end of the first nesting and onset of the second one. On the other hand, the relatively early

end of breeding activity (second week of June) left broad time margins to undertake the moult, extended to the end of August (pers. obs.).

In first broods, the observed growth rate ($k = 0.350$) is very close to the mean growth rate ($k = 0.347$) found in another Alpine population by Breitenmoser-Würsten (1997), also as a consequence of a quite identical asymptotic weight (58.04 vs. 57.5 g). Comparisons with populations breeding in the British Isles are made difficult by different methos, consisting in nestling age estimated within 2-3 days (Ormerod *et al.* 1986; Ormerod and Tyler 1991) and in k values calculated by linear regression in the period of linear growth (O'Halloran *et al.* 1992). However, either including in the logistic model chicks whose age was estimated within 1-2 days or estimating the growth rate by linear regression, the Posina Dippers were featured by higher k values. This difference could be due to larger body size of British Dippers, in accordance with the frequently observed negative relationship between k and asymptotic weight (Ricklefs 1968). The possible negative effect of brood size could be excluded on the basis both of a higher mean number of chicks observed in our population and of the absence of any relationship between nestling development and brood size reported for another Alpine population (Breitenmoser-Würsten 1997).

Baccetti for giving us useful comments and suggestions on earlier versions of this paper.

Riassunto - Tra gli anni 1991 e 1996 è stata studiata la popolazione di Merlo acquaiolo presente lungo il Torrente Posina (Prealpi vicentine). I risultati ottenuti sono stati confrontati con analoghe ricerche condotte in altre regioni europee. I dati relativi alla biometria sono stati raccolti da circa 250 uccelli catturati durante l'intero corso dell'anno. La lunghezza alare di 91.0 mm si è rivelata essere la misura discriminante per la separazione dei sessi. Il peso è variato nel corso dell'anno tra un valore massimo raggiunto nel periodo di muta (agosto) ed un minimo registrato al termine della stagione riproduttiva (giugno). Il tasso giornaliero di crescita dei nidiacei ($k = 0.350$) è risultato molto simile a quello rinvenuto in una popolazione delle Alpi svizzere.

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