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METHODS

OBSERVER ERROR IN MEASUREMENTS OF NESTLING WING LENGTH IN SMALL PASSERINES

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ABSTRACT

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Wing lengths of nestlings of Great Tit *Parus major*, Blue Tit *P. caeruleus* and Pied Flycatcher *Ficedula hypoleuca* measured by one observer (WK) were compared with the measurements taken concurrently by one of 30 other observers. In total 1321 pairs of measurements were analysed. The differences between the measurers were found to: (1) depend on wing length; (2) vary between distinct wing-length classes and species; (3) be bigger in the case of inexperienced measurers (4) be small, only exceeding ± 1 mm in 7% cases and ± 2 mm in 0.5% cases. Such small measurement errors did not significantly bias the wing-length-based age estimation. The average differences between the age estimates derived from wing length taken by WK and other experienced measurers ranged from -0.3 to +0.3 day for various measurers, species and wing-length classes when 1-3 day-old nestlings (1-5 day-old in Blue Tit) were excluded. For the latter nestlings as well as for inexperienced measurers that range was -0.4 – +0.8 day.

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Key words: wing length, nestling age, observer error, measurer bias, Great Tit, *Parus major*, Blue Tit, *Parus caeruleus,* Pied Flycatcher, *Ficedula hypoleuca*.

INTRODUCTION

Wing length is commonly used for age determination in nestlings (*e.g.* Karhu 1973; Tiainen 1978; Törmälä and Kovanen 1979; Kania 1983, 1989). The main reasons for favouring just the wing length as an age index are: its small dependence on the external factors, at least in the case of the biggest nestlings among siblings (O'Connor 1978, Kania 1983), a considerable daily growth rate and ease of taking the measurement in the field. Nestling ageing is particularly needed to calculate the hatching date for phenological analysis. When such investigations are based on the material collected by numerous observers, *e.g.* the ringers (Kania 1983) or Nest Record Scheme recorders, it should be inspected how the variation between measurers can influence the obtained results. So far I have not found any publication dealing with that problem in nestlings. In the present study I address the issue in three passerine hole nesters: Great Tit (*Parus major*), Blue Tit (*P. caeruleus*) and Pied Flycatcher (*Ficedula hypoleuca*).

MATERIAL AND METHODS

The maximum length of a folded wing was measured from the carpal joint to the tip of the longest primary (maximum-chord method, *e.g.* Busse 1983, Svensson 1992) or, when pins of remiges were still absent, to the end of the longest finger, with accuracy to the nearest mm using a stopped ruler. In the smallest nestlings the hand section of the wing was positioned parallel to the body and at the right angle to the forearm.

Wing lengths of nestlings of three passerine species measured by me (WK) were compared with the measurements of the same nestlings taken concurrently by one of 30 other observers in 1986-1998. Altogether 1321 pairs of measurements were analysed, 615 for Great Tit, 272 for Blue Tit and 434 for Pied Flycatcher. Six of the observers measured 83 to 138 nestlings each and fifteen observers – from 23 to 60 nestlings each. They had not been especially trained by me earlier. Both measurers did not know each other's results throughout the field session with the exception mentioned in the text, though the differences were sometimes discussed immediately after measuring all nestmates in the case of two persons. The observers who had previously routinely measured adult passerines or their nestlings were regarded as the experienced ones.

In order to assess the influence of the observer error on the nestling age estimation, I took into consideration the average daily wing growth specific for the given wing length. The average growth as well as age estimations were taken from the wing length – age probability conversion tables prepared with CONTAB computer package (Kania 2003) from the unpublished everyday measurements taken in 1978-2000 in 30 nests of the Great Tit, 13 nests of the Blue Tit and 35 ones of the Pied Flycatcher. The differences in measurements were tested with ANOVA. Probability level $p = 0.05$ was accepted as significant.

RESULTS

The disagreement in measurements taken by different observers arose from various wing positioning, different number rounding or from misreading of the rule. Two kinds of reading mistakes were found. When the end of the wing reached the mark on the scale preceding the longer mark denoting successive 10 or 5 mm, the measurer sometimes added 1 instead of subtracting it (thus obtaining, *e.g.* 16 instead of 14), or *vice versa*, subtracted 1 instead of adding. Errors of this kind are undetectable afterwards and may occur in the material. There were also mistakes by 5 or 10 marks. Some of those were found during measuring whereas seven errors could be recognised in data processing as distinct outliers. In the former case the observers were asked to re-measure the birds after being informed of the type of the error, while in the latter ones the measurement was discarded.

As the influence of the measurement error on age estimation depends on the wing length (Fig. 1), I divided the wing-length range into three classes within which the effect of a 1-mm error on the age estimation was similar (Table 1). The mean measurement differences between measurers were bigger in nestlings with longer wing (Table 2), whereas their impact on the age estimation was smaller (Fig. 1). The differences in measurements performed by myself and some other observers in some wing-length classes and in all species (Tables 3-5) were significant (in Great Tit wing-length classes were as follows: $p < 0.001$, $F_{6,92} = 7.80$; $p = 1.0$; $p < 0.0001$, $F_{16,426} = 25.9$; in Blue Tit: $p < 0.001$, $F_{4,128} = 7.2$; $p = 0.60$, $F_{2,12} = 0.53$; $p < 0.001$, $F_{9,114} = 24{,}5$; in Pied Flycatcher: $p = 0.94$, $F_{2,23} = 0.06$; $p = 0.25$, $F_{2,28} = 1.46$; $p < 0.001$, $F_{10,362} = 11.7$). Some observers' measurements differed from mine in quite another way in various wing-length classes (Tables 3-5) or various species (Table 6). Particularly variable in respect to wing-length classes were the measurements taken by observer 8 (Table 3 and 4). Observer 12 differed oppositely in Great and Blue Tits in wing-length classes 2 and 3 (Table 6).

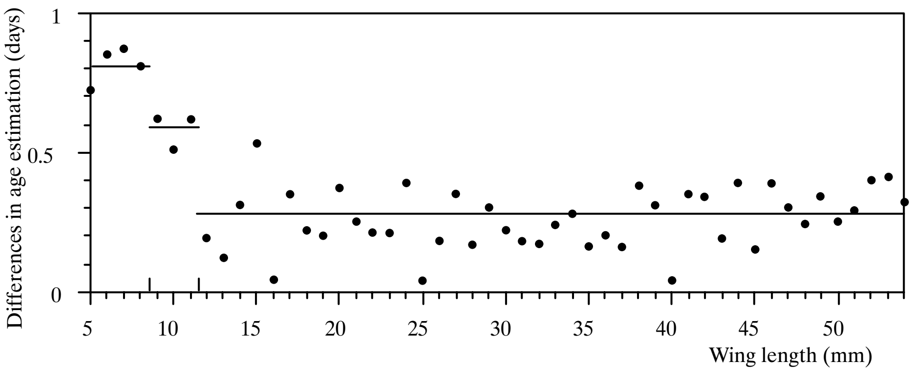

Fig. 1. How errors in measuring wing-length by 1 mm alter the age estimation in dependence on wing length in the Great Tit (*Parus major*) nestlings. Mean ages for particular wing lengths were taken from the wing length – age conversion table (Kania unpubl.). Averages for wing-length classes (marked on abscissa) are indicated by horizontal lines.

Table 1
Average increase of estimated age with 1-mm increment of the wing length

Wing-length class	*Parus major*		*Parus caeruleus*		*Ficedula hypoleuca*	
	Wing-length range (mm)	Age increase (day)	Wing-length range (mm)	Age increase (day)	Wing-length range (mm)	Age increase (day)
1	5-8	0.81	5-9	0.88	6-8	0.84
2	9-11	0.58	10-11	0.56	9-12	0.47
3	12-59	0.28	12-54	0.26	13-56	0.23

Table 2
Distribution (%) of the differences in wing-length measurements taken by different observers in relation to the wing lengths measured by WK (W. Kania).
Data for Great and Blue Tits and Pied Flycatcher as well as for experienced and inexperienced observers pooled.

Wing-length by WK (mm)	*n*	Differences (mm)								
		-3	-2	-1	**0**	+1	+2	+3	+4	+5
5- 8	239			7.5	**73.6**	18.4	0.4			
9-11	130			17.7	**63.1**	18.5	0.8			
> 11	945	0.1	2.3	20.0	**43.9**	24.1	7.9	1.1	0.4	0.1

Table 3
Mean differences between wing-length measurements taken by WK and other observers and between age estimations based on those measurements in the Great Tit nestlings.
The largest differences within wing-length class (in plus and in minus) – in bold.

Observer	Experience	Wing-length classes and ranges as measured by WK								
		1			2			3		
		5-8 mm			9-11 mm			12-59 mm		
		mm	days	*N*	mm	days	*N*	mm	days	*N*
1	+							**-1.0**	**-0.3**	**47**
2	+[1]	0.4	0.3	25	-0.2	-0.1	28	0.9	0.3	14
3	+							0.2	-0.1	38
4	-							-0.1	-0.0	47
5	-							0.0	0.0	42
6	+	-0.3	-0.2	10						
7	-							0.9	0.2	8
8	+	**0.6**	**0.5**	**7**				-0.5	-0.1	62
9	+							-0.2	-0.1	8
10	-							1.2	0.3	10
11	-	-0.1	-0.1	8				1.8	0.5	8
12	+[1]	0.0	0.0	25	-0.2	-0.1	28	0.7	0.2	14
13	+							0.4	0.1	21
14	+							0.2	0.0	29
15	-							**2.3**	**0.6**	**22**
15	+	**-0.5**	**-0.4**	**8**				-0.4	-0.1	8
16	-							0.4	0.1	17
Others[2]	+ and -	-0.3	-0.2	16	-0.2	-0.1	14	0.7	0.2	48

[1] Differences often discussed during field session.
[2] With < 7 measurements for a observer and wing-length class

Table 4
Mean differences between wing-length measurements taken by WK and other observers and between age estimations based on those measurements in the Blue Tit nestlings. The largest differences within wing-length class (in plus and in minus) – in bold.

Observer	Expe-rience	Wing-length classes and ranges as measured by WK								
		1			2			3		
		5-9 mm			10-11 mm			12-54 mm		
		mm	days	*N*	mm	days	*N*	mm	days	*N*
2	+[1]	0.3	0.3	55	0.0	0.0	7	0.4	0.1	9
3	+	**0.7**	**0.6**	7				0.1	0.0	23
5	-							0.8	0.2	20
6	+	**-0.1**	**-0.1**	7						
8	+	0.0	0.0	9				**-0.7**	**-0.2**	17
12	+[1]	0.0	0.0	55	0.3	0.2	7	0.0	0.0	9
13	+							0.4	0.1	10
14	+							0.0	0.0	10
15	-							**3.0**	**0.8**	10
16	+							0.3	0.1	10
Others[2]	+ and -				(0.0)	(0.0)	1	1.8	0.4	6

[1,2] see Table 3

Table 5
Mean differences between wing-length measurements taken by WK and other observers and between age estimations based on those measurements in the Pied Flycatcher nestlings. The largest differences within wing-length class (in plus and in minus) – in bold.

Observer	Expe-rience	Wing-length classes and ranges as measured by WK								
		1			2			3		
		6-8 mm			9-12 mm			13-56 mm		
		mm	days	*N*	mm	days	*N*	mm	days	*N*
3	+	**0.3**	**0.2**	**14**	0.6	0.3	7	0.6	0.1	28
5	-	0.2	0.2	9				-0.1	-0.0	18
9	+							0.3	0.1	67
17	-							0.7	0.2	25
18	-							**0.8**	**0.2**	**26**
19	+							-0.1	-0.0	42
20	-				**0.7**	**0.3**	**12**	0.2	0.0	19
21	-							**-0.3**	**-0.1**	**60**
22	+							-0.3	-0.1	54
23	+							0.7	0.2	31
Others[2]	+ and -	(0.3)	(0.2)	3	0.2	0.1	12	(-0.3)	(-0.1)	3

[2] see Table 3

Table 6
A comparison of the species-specific mean differences between wing-length measurements taken by WK and other measurer. Significance of differences given if $p < 0.10$.

Observer	Species	Wing-length classes 1 mm	1 N	1 p	2 mm	2 N	2 p	3 mm	3 N	3 p
2 +[1]	*P. major*	0.4	25		-0.2	28		0.9	14	
	P. caeruleus	0.3	55		0.0	7		0.4	9	
3 +	*P. major*							0.2	28	$F_{2,86} = 2.77$ $p = 0.07$
	P. caeruleus	0.7	7					0.1	23	
	F. hypoleuca	0.3	14					0.6	28	
5 -	*P. major*							0.0	42	$F_{2,77} = 9.2$ $p = 0.00003$
	P. caeruleus							0.8	20	
	F. hypoleuca							-0.1	18	
6 +	*P. major*	-0.3	10							
	P. caeruleus	-0.1	7							
8 +	*P. major*	0.6	7	$F_{1,14} = 4.85$ $p = 0.04$				-0.5	62	
	P. caeruleus	0.0	9					-0.7	17	
9 +	*P. major*							-0.2	8	$F_{1,73} = 5.1$ $p = 0.03$
	F. hypoleuca							0.3	67	
12 +[1]	*P. major*	0.0	25		-0.2	28	$F_{1,33} = 7.5$ $p = 0.01$	0.7	14	$F_{1,21} = 5.4$ $p = 0.03$
	P. caeruleus	0.0	55		0.3	7		0.0	9	
13 +	*P. major*							0.4	21	
	P. caeruleus							0.4	10	
14 +	*P. major*							0.2	19	
	P. caeruleus							3.0	10	
15 -	*P. major*							1.6	30	$F_{1,38} = 9.2$ $p = 0.004$
	P. caeruleus							3.0	10	
16 +	*P. major*							0.4	17	
	P. caeruleus							0.3	10	

[1] see Table 3

Although often significant, the differences were small. In the case of nestlings with wing length up to 11 mm in all three species the mean differences between measurements taken by myself and any other observer did not exceed -0.5 and +0.7 mm which resulted in differences in age estimated up to -0.4 and +0.6 day. In bigger nestlings, the average differences were up to -1.0 and +1.8 mm or -0.3 and +0.5 day with the exception of the inexperienced measurer 15 (Table 3 and 4) where the wing length was 0.5-1.2 mm shorter than that of the next observer with the smallest measurements. A few years later, after gaining some experience, the same measurer did not show such an extreme differences in measurements compared with the others (Table 3). After excluding the data collected by that observer when still inex-

Table 7

Mean differences between wing-length measurements taken by WK and other experienced or inexperienced observers and between age estimations based on those measurements. The significance of differences between experienced *versus* inexperienced measurers in disagreement of their mean wing-length measurements in comparison to WK: * – $p = 0.03$; ** – $p < 0.001$.

	Experience	Wing-length classes								
		1			2			3		
		mm	days	*N*	mm	days	*N*	mm	days	*N*
P. major	+	0.1	0.1	77	-0.2	-0.1	64	-0.1	-0.0	264
	-							0.6**	0.2	173
	-[1]	-0.2*	-0.2	22	-0.5	-0.3	6	0.4**	0.1	151
P. caeruleus	+	0.2	0.2	133	0.1	0.0	16	0.0	0.0	88
	-							1.6**	0.4	36
	-[1]							1.1**	0.3	26
F. hypoleuca	+	0.3	0.2	15	0.5	0.2	13	0.2	0.0	225
	-	0.3	0.2	11	0.4	0.2	18	0.1	0.0	148

[1] – observer 15 excluded

perienced, the measurements equal to mine or differing only by 1 mm were obtained by other observers in 93% cases, whereas those equal or differing by not more than 2 mm – in 99.5% cases. The differences were usually higher for the inexperienced observers than for the experienced ones in both tit species, but not in Pied Flycatcher (Table 7). The differences between the average wing lengths taken by observers with the shortest or longest wing measurements reached 1.2, 0.9 and 4.0 mm in consecutive wing-length classes, *i.e.* 1.0, 0.4 and 1.1 day of estimated age in the three pooled species under investigation. For the experienced measurers those differences in 2nd and 3rd wing-length classes were 0.8 and 1.9 mm or 0.4 and 0.5 day respectively (Tables 3-5).

DISCUSSION

While, according to my knowledge, an analysis of observer variation in wing length measurements has not been performed for nestlings so far, the problem has been investigated in full-grown birds from a range of taxa (*e.g.* Johanesson 1967, Barret *et al*. 1989, Gosler *et al.* 1995, Morgan 2004). Those papers also characterised wing length as a trait comparatively slightly affected by the measurer error. Although the differences in nestling measurements taken by various observers were often statistically significant, they remained small and without noticeable effect on the age estimation (even in the case of inexperienced observers), especially in the nestlings in 2-3 classes of wing length (*i.e.* after 3rd-4th day of life, Kania unpubl.).

Then even the biggest possible errors were small in comparison with daily wing-length growth rate – above 4 mm in 3rd wing-length class in investigated species (Kania unpubl.). The error was higher in the first days of life, when a difference of 1 mm contributed to 20% of the wing length, and the daily growth rate could have been lower than the accuracy of the measurement. In that case the age estimate for particular nestlings can be biased by about one day.

The tendency for inexperienced measurers to obtain shorter wing lengths, found for the nestlings, was also reported for full-grown birds (Gosler *et al.* 1995).

Except for the errors resulting from the measuring techniques, there were found ruler misreading or mistakes in recording the measurements (also by Barret *et al*. 1989 and Morgan 2004), though they are not analysed quantitatively here. Morgan (2004) additionally referred to the gap between "stop" and the scale's zero on the some stop ruler, which reached 0.3 mm.

The impact of the measuring error on the age estimation should be even smaller in the species showing a bigger wing-length growth rate, *i.e.* the ones with a shorter growth period or bigger size or both, as it is *e.g.* in the Red-winged Blackbird (*Agelaius phoeniceus*), which showed the wing growth of up to 8 mm daily (Holcomb and Twiest 1971). On the other hand, the absolute measuring error can increase with the rise in wing length and the stiffness of primaries together with the growth in the dependence of the measured value on the correctness in flattening and straightening of the wing. The greater imprecision of wing length measurements in larger species was found in full-grown birds by Gosler *et al*. (1995).

CONCLUSIONS

Though the differences in wing length measurements taken in the same nestlings by various measurers may be statistically significant in three passerine species studied, they are small and usually can bias the wing-length-based age estimation by less than half a day. Only in the first days of nestling life or in the case of inexperienced observers showing exceptionally short wing measurements, the bias can approximate to one day.

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