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Absolute length of third primary: an intriguing peculiarity of utterly useless metric

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Introduction

The morphometry of avian flight apparatus is a highly exciting field, offering wide arrange of possibilities of evolutionary, biogeographical or ecological interpretations. Unfortunately, the relevant literature has been plagued by incomparability: various groups (“schools”) of scientists, or even individual authors, apply different indices, based on different and differently presented metrics, different statistical tests, original data are usually camouflaged in form of logarhythms, principal components, &c., &c., &c., what makes the possibility to compare and/or exploit the published data and results between authors and projects very difficult or (usually) impossible! One of such “unorthodox” ideas was LOCKWOOD & *al.*’s (1998) suggestion to replace “primary distances” (the distance between the tip of folded wing and tips of particular primaries) by “primary lengths” (length of each primary as measured from its insertion in the skin to the tip) in analyses of wing formulae. This approach has become rather popular, but – as shown *e.g.* by GOSLER & *al.* (1995), BUSSE (2000) and myself (HOŁYŃSKI 2018) – its alleged advantages are based on misinterpretations while serious flaws are perfectly real. Still earlier, BERTHOLD & FRIEDRICH (1979), having noticed the strict correlation between so measured length of the 8th (in their interpretation, *i.e.* 3rd according to the numeration accepted here) primary and wing length, suggested to use the latter as the – in their opinion – “better” substitute of the former.

In (not only) my opinion the measurement of the 3. primary is neither more exact not safe for the bird (see HOŁYŃSKI 2018 for more deailed argumentation), thus just the strict correlation with widely used, comprehensively tested, directly interpretable traditional wing length makes the proposed metric glaringly useless, devoid of any potential to provide additional information. So I had not hitherto paid much attention to it, in particular I did not meditate on the extent of this strict correlation: BERTHOLD & FRIEDRICH (1979) established its

validity within two sparrow species, and I subconsciously accepted it as an uninteresting intraspecific phenomenon. It was only at the beginning of this year, when I started to analyse (for quite another project) the morphometric data of several species from NE-Hungary whose wing formulae had been kindly measured (on my special request: in the last years Hungarians have introduced measurements of 3. primary instead [*sic!*] of formulae) by Enikő BARTHA-PETRILLA (PETRILLANÉ BARTHA Enikő according to the Hungarian version of the name), that it struck me that the remarkably strict proportionality between 3. primary and wing length holds also among species: with but few exceptions, likely resulting from imprecision of measurements (1 mm. difference, or even rounding halves up or down, means in case of most passerines 1.5-2% of wing length!), in all species with more than 1 ex. measured the average length of 3. primary was between 75 and 77%! The aim of the present paper is to signalize somewhat mysterious consequences of such stability, leaving a feasible evolutionary, anatomical or aerodynamical explanations to more qualified Colleagues.

Explanation of terms:

Basal distance: distance between anterior surface of carpal joint and point of insertion of a remex in the skin

Feather length: length of the part of a remex between insertion to skin and tip

Retraction: distance between the tip of a remex and the tip of the (folded) wing (HOLYŃSKI 2018)

Outstretched: primaries whose tips are close to the tip of the wing

Abbreviations:

N	=	number of measured 3 rd primaries
W	=	wing length
B	=	basal distance
L_x	=	length of the x th primary
R_x	=	retraction the x th primary
K	=	length of wing-tip (KIPP's index)
a	=	qualitative index of pointedness (HOLYŃSKI 1965)
E	=	quantitative index of pointedness (HOLYŃSKI 1965)
L	=	index of elongation (BUSSE 1967)

[all – except **a** and **w** – normalized as % of **w**]

At the first glance, the interspecific nature of the correlation does not seem surprising, but a moment of reflexion suffices to realize the not easily interpretable aspect: what about the differences in wing formulae? In terms of formulae, wing length is composed of three components: the distance (**B**) from the “base” (carpal joint) of folded wing to the insertion of a remex in the skin (symbolized by thin oblique line in lower part of [fig. 3](#) and [4](#)), the length (from the insertion to tip: **L**) of the remex, and retraction (**R**: the distance between its tip and that of the wing – see HOLYŃSKI 2018 for the justification of the term). That latter component varies between species in accord with the variability of wing formulae, what (in case of relative values: percents of wing length) should automatically result in compensative change in at least one of the other two. Intuitively points of insertion (**B**) seem anatomically fixed, so we would rather expect the negative relationship between retraction and length of the feather. In the case of 3. primary **R₃** is usually small, so the reduction of **L₃** may also be less obvious than in other remiges, but anyway should be noticeable. Surprisingly, it is not: **L₃** remains totally unrelated to **R₃** ($r=-0,12$; [fig. 1](#))!

Lack of significant correlation with **R₃** (or with any other variable – see [Table 1](#)) leads to the conclusion that, indeed, in relative terms (proportion of wing length) **L₃** is also interspecifically stable (at *ca.* 76.20 ± 0.18); this conclusion is confirmed by **L₃+R₃** being much more strongly ($r=0,76$; [fig. 2](#)) correlated with **R₃** than with **L₃** ($r=0,56$).

	N	L ₃	R ₃	K	a	E	L	W	L ₃ +R ₃
<i>Locustella luscinioides</i>	1	73.91	1.45	31.88	10.00	73.91	73.91	69.00	75.36
<i>Troglodytes troglodytes</i>	20	74.17	0.75	15.41	2.16	6.28	27.23	48.75	74.92
<i>Sturnus vulgaris</i>	11	74,24	0,76	39,39	9,67	85,37	85,71	124,36	75,00
<i>Picus canus</i>	1	75,17	2,07	24,83	0,50	6,90	46,90	145,00	77,24
<i>Parus montanus</i>	1	74.60	4.57	18,27	-1.07	-7.59	34.78	63.00	79.17
<i>Certhia brachydactyla</i>	1	75.41	3.28	16.39	0.50	4.92	44.26	61.00	78.69
<i>Oriolus oriolus</i>	9	75,49	0,00	29,74	8,00	71,78	83,78	152,78	75,49
<i>Regulus ignicapillus</i>	2	75.46	1.89	24.47	0.75	5.63	33.97	53.00	77.35
<i>Phylloscopus trochilus</i>	27	75.62	0.03	25.91	6.28	35.60	51.48	65.39	75.65
<i>Aegithalos caudatus</i>	46	75.73	4.13	22.77	0.24	-3.32	40.82	62.29	79.86
<i>Phylloscopus collybita</i>	32	75.82	0.33	20.24	3.21	12.29	35.10	60.38	76.15
<i>Parus palustris</i>	20	76.03	3.39	18.79	-0.48	-4.85	35.02	63.20	79.42
<i>Serinus serinus</i>	1	76.06	0.00	30.99	6.50	43.66	49.30	71.00	76.06
<i>Lanius collurio</i>	24	76.32	0.00	28.76	7.70	49.86	60.77	91.33	76.32
<i>Turdus iliacus</i>	13	76.42	0.17	32.04	7.39	56.69	64.16	117.15	76.59
<i>Turdus philomelos</i>	30	76.47	0.02	29.91	7.25	53.28	59.78	115.20	76.49
<i>Delichon urbicum</i>	5	76.50	1.26	53.72	10.00	123.89	123.89	110.60	77.76
<i>Turdus merula</i>	9	76,60	1,46	22,75	3,77	22,08	43,09	127,22	78,06
<i>Ficedula hypoleuca</i>	9	76,69	0,03	30,43	6,61	47,10	60,69	79,67	76,72
<i>Certhia familiaris</i>	18	76.70	3.27	18.47	1.03	7.75	42.27	63.44	79.97
<i>Parus ater</i>	19	76.73	2.21	21.45	1.42	7.33	39.45	61.53	78.94
<i>Motacilla alba</i>	8	76.77	0.00	31.71	8.50	65.00	66.28	89.88	76.77
<i>Parus caeruleus</i>	12	76.78	1.70	20.47	1.10	4.56	35.40	65.33	78.48
<i>Upupa epops</i>	9	76,79	2,84	20,00	2,00	11,61	46,71	147,56	79,63
<i>Turdus pilaris</i>	17	76.83	0.00	29.25	7.61	57.41	64.43	144.18	76.83
<i>Sitta europaea</i>	31	77.08	0.81	21.94	3.78	22.43	39.76	85.42	77.89
<i>Picoides major</i>	7	77,09	1,90	29,30	2,67	19,53	53,13	132,29	78,99
<i>Phylloscopus sibilatrix</i>	3	77.44	0.00	30.10	7.83	56.66	64.60	75.33	77.44
<i>Hirundo rustica</i>	61	77.61	1.54	53.10	9.98	115.69	115.69	123.18	79.15
<i>Hippolais icterina</i>	1	77.82	0.00	29.72	7.75	52.55	60.15	79.00	77.82
Mean or correlation		76,20	-0,12	0,01	0,02	-0,01	-0,04	-0,30	0,56

Table 1

Biometric indices of the examined species

Bottom row: **overall average of L₃** and **coefficient of correlation of the particular index and L₃**
 Black: measured on the NE Hungarian birds (including migrants); red: values taken from other samples

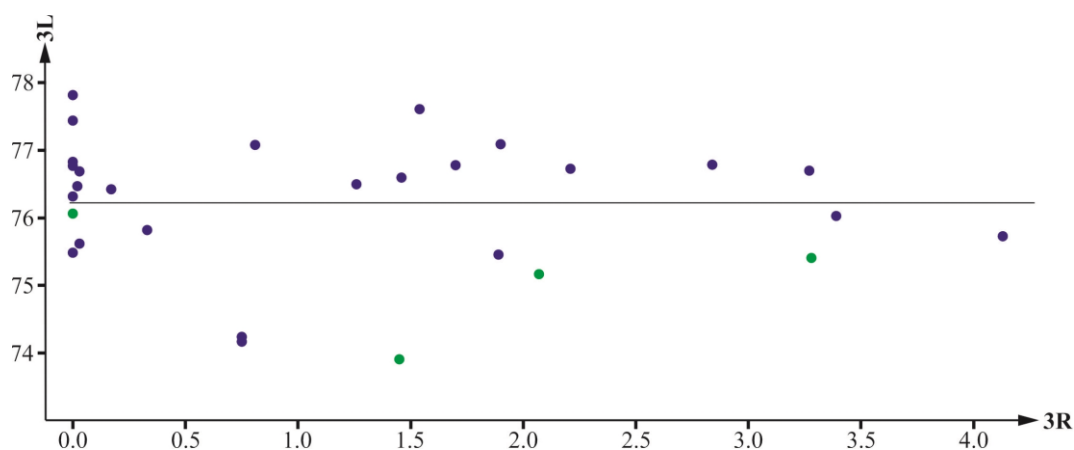


Fig. 1

Length of 3. primary as function of its retraction

Green: measured on less than 3 individual birds

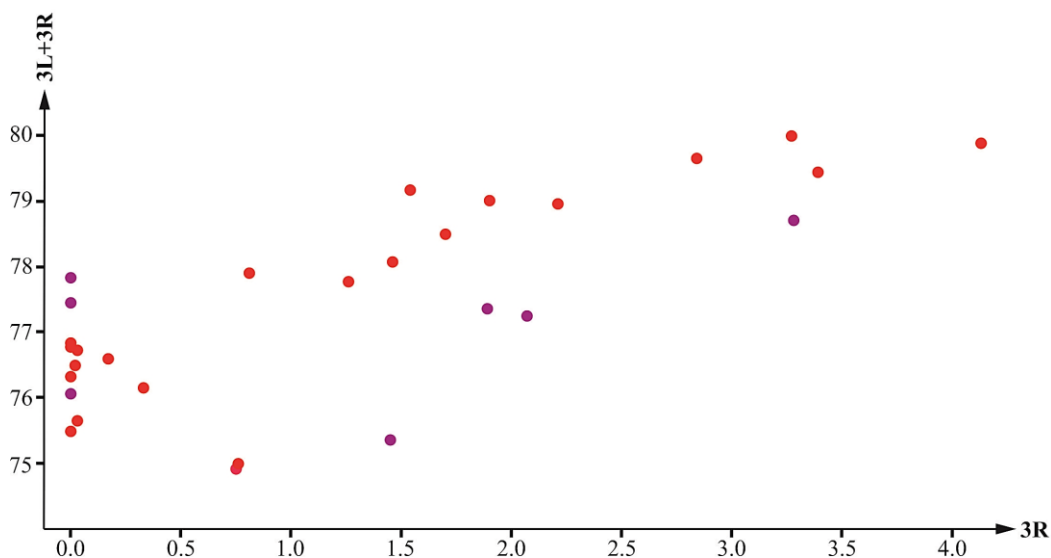


Fig. 2

Sum of length and retraction of 3. primary as function of its retraction

Purplish: measured on less that 3 individual birds

In typical ten-primaried passerines third primary is attached to the penultimate joint of the skeleton of 2. finger (STEGMANN 1962); base of the 2. primary is at the tip of that joint, 1.p. (the remicle) at the tip of the distal joint, whereas the 4., 5., &c. primaries are fixed more proximally (schematic oblique line on figs. 3 and 4). In moderately rounded wings, where 3. primary makes the tip of the wing, the invariability of its (relative) length allows to calculate the basal distance: $B=W-L_3=100-76.20=23.80\%$ (⊙ on figs. 3 and 4); unfortunately, I have no data on the lengths of other primaries, so the oblique line symbolizing their basal distances is here but a schematic indication of the general idea.

Intuitively, the evolution (fig. 3) of a moderately rounded (here exemplified by *Phylloscopus trochilus* – green markings: •) wing into more pointed (like e.g. in *Delichon urbicum* – red •) may be conceived as elongation of distalmost aerodynamically effective (2th) primary with correlated, assuring functionally optimal shape, progressively less and less marked increase of the length of consecutively more proximal ones. Evolutionary transformation into more rounded (say, that of *Parus palustris* – blue •) wing should, conversely, involve shortening (also most conspicuous in distal, progressively less so in proximal) of primaries. Natural result of increase or reduction of the length of most outstretched (making the wingtip) primaries is the according change of the absolute length of the wing; as we are herein interested in relative values, all formulae must be retransformed “back” to percentages. But now (fig. 4) the 3. primary looks definitely shorter as well in the most pointed as in more rounded wings than in intermediate ones, what apparently contradicts its – demonstrated above – invariability.

If, nevertheless, the length of 3. primary is indeed stable, i.e. if greater R_3 is *not* compensated by shortened L_3 , then there seems to remain only one – even if intuitively the least likely [translocations connected with disappearance of remicle in “nine-primaried” birds (STEGMANN 1962) seem here at most marginally relevant] – possibility: displacement of the insertion point of the remex. So, was the invariability of the length of 3. primary evolutionarily/functionally more important than stability of implantation pattern of remiges? Or, conversely, stable length of 3. primary is but an accidental side effect of correlated changes of wing shape and skeletal relations? I cannot venture into attempts to clarify the

anatomical details and functional interpretation, so I leave this to more qualified Colleagues having access to data on length of other (not only the 3rd) primaries.

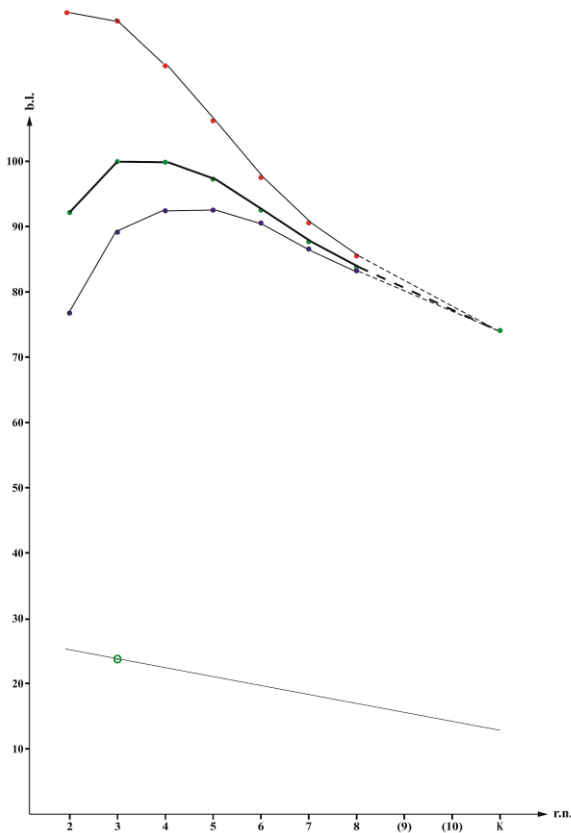


Fig. 3

Evolution into more pointed or more rounded wings

(explanations in the text)

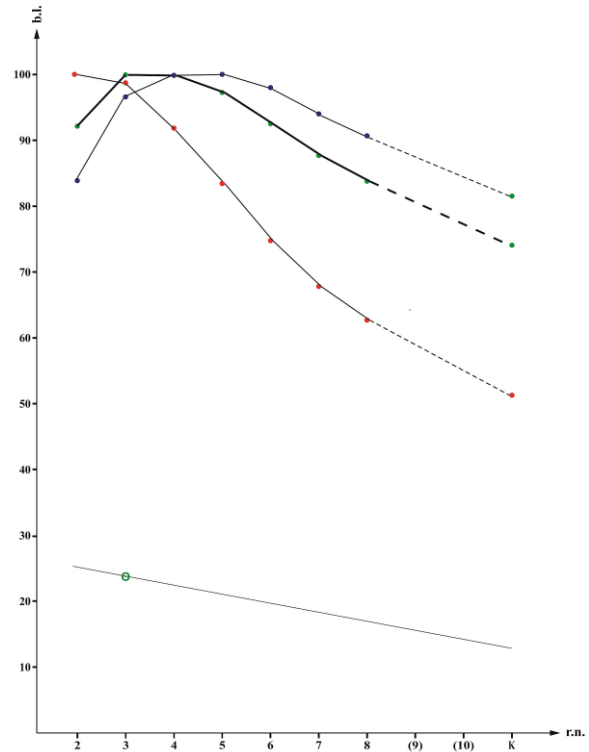


Fig. 4

Result of evolution of pointed or rounded wings

Acknowledgements

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