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Body proportions in adults and fledgelings of the Little Auk

[With 1 text-fig.]

Proporcje w budowie ciała dorosłych i wylatujących traczyków lodowych

Abstract. The comparative analysis carried out in this work included the external dimensions of the body, the area and shape of the wings and paddles, the size of the skull, breastbone, shoulder girdle and limbs, and the weight of certain muscles and the heart of adult Little Auks and their fledgelings at the time of their flying out of the breeding colony. It appeared that the body proportions of juveniles are theoretically more advantageous than those of the adults so far as their fitness for flight is concerned. The wings of 26-day-old Little Auks are less loaded, have a more advantageous shape and a larger relative area. The size of the bones of their shoulder girdle and limbs resembles their final dimensions. The relative weight of the pectoral muscles is similar to that of the adults. The relative weight of the heart of the fledgelings is nearly one and a half times as large as that of the adult birds. The body proportions which young Little Auks reach at the time of their departure from the colony result to a great extent from the pre-fledging loss of weight.

I. INTRODUCTION

The Little Auk *Plautus alle* (LINNAEUS, 1758) is the smallest species of the Atlantic alcids. Owing to its small size, it moves with much more expedition both in the air and on the hard ground than do the big species. On the other hand, it finds it difficult to dive for a long time and to swim under water (STORER, 1971).

Chicks of the Little Auk are semiprecocials (SEALY, 1973); they remain in the breeding colony for an average of 27 days (STEMPNIEWICZ, 1981) and then shorter than other semiprecocial alcid species. This is connected with the very high growth rate of chicks (the highest value of the constant of growth K in the *Alcidae*) and their having the relatively smallest body size at the time of departure (STEMPNIEWICZ, 1980, 1981). Young Little Auks do not take wing till that moment; thus, the departure to sea is the first flight in their life and in great measure a conclusive one as regards their survival (STEMPNIEWICZ, 1981).

The purpose of this work was to compare the body proportions of adualt and 26-day-old (just before their leaving the breeding colony) Little Auks from the angle of the theoretical locomotor capacity of these two age groups.

II. MATERIAL AND METHODS

Material for the present work was collected in a breeding colony of Little Auks, situated on the northern shore of Hornsund in South-West Spitsbergen in 1975. Ninety-seven adult birds were captured in mits-nest and standard outer measurements were taken on them. Thirteen of them were put to sleep with ether. Prior to their being preserved in 4% formalin the surface area of the wings and paddles, the length of the alula, the length and width of the

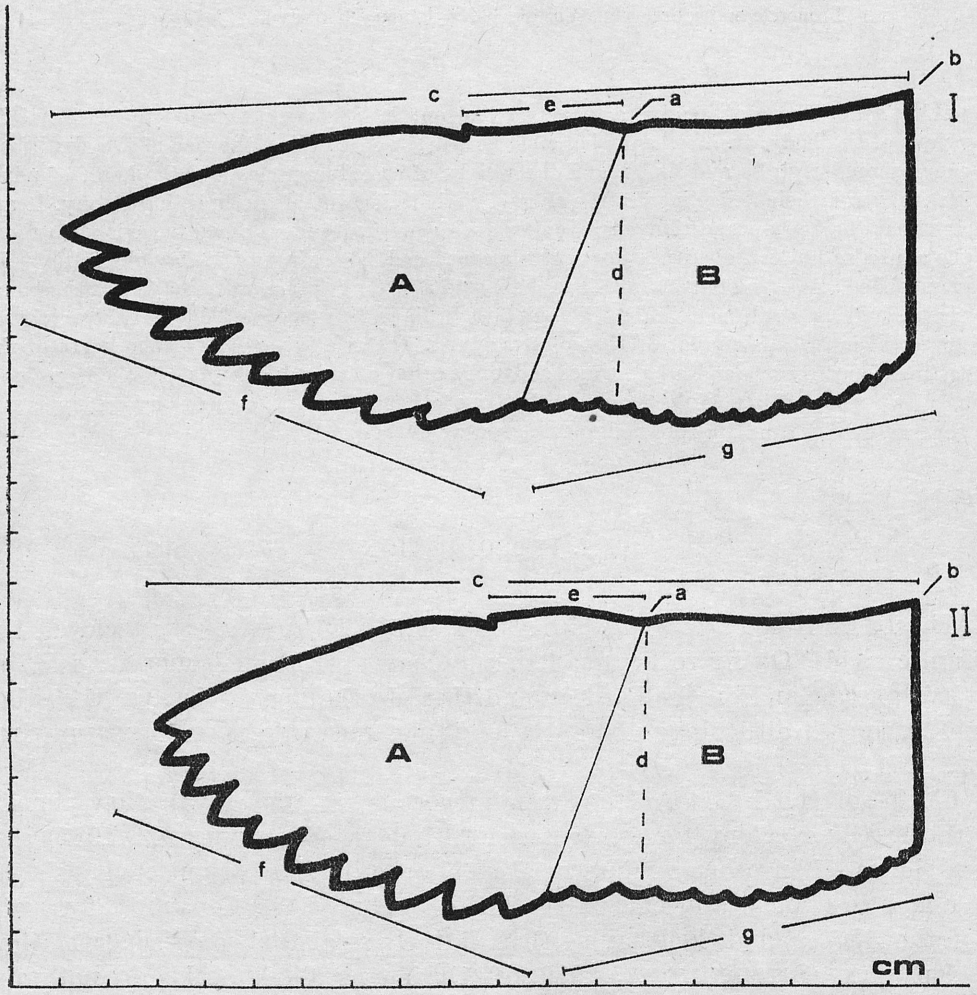

Fig. 1. The outline of the wing of the Little Auk (I — adult, II — fledgeling). A — distal part of wing, B — proximal part of wing; a — wrist joint, b — shoulder joint, c — overall length of wing, d — width of wing, e — length of alula, f — primaries, g — secondaries

spread wing were measured (Fig. 1) by the method employed by STORER (1954) and RAIKOW (1973). These measurements were used to calculate the loading of wings (body weight/area of wings, after GLADKOV, 1949), the loading of paddles (body weight/area of paddles), the relative area of the wings ($\sqrt{\text{area of wings}}/\sqrt[3]{\text{body weight}}$, after RAIKOW, 1973), the relative area of the paddles ($\sqrt{\text{area of paddles}}/\sqrt[3]{\text{body weight}}$, afer RAIKOW, 1973) and other indices (see Table II).

The fixed specimens were next subjected to laboratory treatment. They were rinsed in running water for 1 hour and subsequently some of their muscles and the heart were removed, using the same method for all the birds being dissected. In order to simplify the method for the exicision of muscles and to obtain comparable results, only the pectoral muscles and the muscles of the hind limb together with its skeleton were included, just as practised by ANDERSON (1972). The group of pectoral muscles consisted of all the muscles enclosed by the breastbone, sternal keel, clavicle and shoulder joint. The weight of the hind limb was the sum of the weight of all its muscles and that of its skeleton. Both the muscles and the heart, removed in the same manner from the body of each bird and cleared of the connective tissue, were drained for 5 minutes on filter tissue in a closed glass vessel. Next they were weighed, using an analytical balance, to an accuracy of 0.01 g.

In the following stage of laboratory preparation the selected skeletal elements, i. e. the bones of the skull, breastbone, shoulder girdle and limbs, were removed, cleaned and measured by means of a slide caliper to an accuracy of 0.1 mm. A total of 24 skulls and sternal keels were measured, for these elements obtained from 11 specimens found dead in the colony area were added to the material.

The measurements of the skull consisted of the greatest length of the skull (together with the ramphotheca), the length of the premaxillary (with the ramphotheca) and both the greatest and the smallest interorbital width of the neurocranium. Several indices of the skull shape were also calculated. (see Table IV).

As regards the breastbone, the length of the keel and its greatest height were measured. The area of the surface for the attachment of the pectoral muscles was calculated, assuming that it has the shape of two triangles on each side of the body. The length and the greatest height of the sternal keel form the sides of one triangle and the length of the sternal keel and that of the coracoid are the sides of the other.

The measurements of the shoulder girdle include the greatest lengths of the coracoid, scapula and clavicle. The measurements of the skeleton of the wing were reduced to the greatest lengths of the humerus and the bones of the forearm and palm (carpometacarpus and phalanges of digit 2). The measurements of the skeleton of the hind limb consisted of the greatest lengths of the femur, tibiotarsus, tarsometatarsus and phalanges of digit 3.

The global length of the bones that make up the shoulder girdle, the global length of the bones of the wing and the global length of the bones of the hind limb were used in biometric comparisons. The measurements of the surface area of the wing and paddle, the weight of the pectoral muscles and that of the muscles of the leg concerning one side of the body were doubled to obtain the actual values.

The external measurements of young Little Auks (on the 26th day of life) are taken from a work by STEMPNIEWICZ (1980). Seventeen young birds, whose age is known accurately, were put to sleep with ether so that the measurements of their skeleton, muscles and heart might be taken. The further stages of investigation (fixation, preparation and measurement) were the same as with adult birds.

III. RESULTS

1. Standard external measurements

Immediately before leaving the breeding colony young Little Auks differ distinctly in body dimensions from the adult birds (Table I). Their body dimensions are generally smaller except the length of the tarsus, which is similar in both groups. The strong development of the tarsus in chicks is a frequent phenomenon in the semiprecocial species of the *Charadriiformes* (KOZLOVA, 1957). The body weight of young Little Auks has a relatively lowest value. This is to a large extent due to the pre-fledging weight loss which immediately follows their maximum in body weight, on the average on 20th day of life (STEMPNIEWICZ, 1980). Attention should be given also to the differences in beak length between the two groups of birds. This character, mentioned by many authors (DEMENTEV et al., 1951; KARTASCHEW, 1960; KOZLOVA, 1957), makes it possible to distinguish juveniles in the first winter of life from adult birds.

Table I

Standard external dimensions of adult and juvenile Little Auks

Measurement	Adults (a)	N	SD	Fledgelings (f)	N	SD	$\frac{f}{a} \times 100$ (%)
Body weight (g)	163.1	96	12.0	109.8	30	10.1	67.3
Length of folded wing* (mm)	120.5	97	3.2	97.9	31	3.6	81.3
Length of beak (mm)	15.8	91	0.7	12.1	38	0.6	76.5
Length of tarsus (mm)	21.8	97	0.8	21.9	36	0.8	100.2
Length of tail (mm)	33.5	97	2.4	28.6	31	1.8	85.6

* flattened wing (SVENSSON 1975).

2. Area of wings and paddles and wing shape

The wings and paddles of young Little Auks are smaller in area than those of the adult birds (Table II). However, relative to the body weight these areas compare to advantage with the corresponding values for the adults. Both the wings and the paddles of the fledgelings are less loaded and their relative areas exceed those in the adults.

Table II

Area, shape and loading of wings and paddles of adults (N = 13) and fledgelings (N = 17) of the Little Auks. A — area of distal part of wing, B — area of proximal part of wing, C — overall length of wing, D — width of wing, E — length of alula, S — length of folded wing

Measurement	Adults (a)	SD	Fledgelings (F)	SD	$\frac{f}{a} \times 100$ (%)
Area of wings (cm^2)	173.23	8.60	140.81	10.15	81.3
Area of paddles (cm^2)	11.80	0.84	9.60	0.61	81.4
Loading of wings (g/cm^2)	0.98	0.06	0.79	0.07	80.6
Loading of paddles (g/cm^2)	14.35	1.13	11.47	0.98	79.9
Relative area of wings	2.38	0.06	2.47	0.09	103.8
Relative area of paddles	0.62	0.02	0.65	0.02	104.8
A/B	1.30	0.10	1.10	0.08	84.6
C/D	2.99	0.11	2.76	0.10	92.3
E/S	0.29	0.01	0.35	0.01	120.7

The shape of the wings of young Little Auks is also different. The wings are relatively shorter and wider than in the adult birds and the area ratio of the distal part of the wing to the proximal is distinctly smaller in them (Table II). This is caused by the fact that the primaries of the fledgelings are less advanced in development than the secondaries. The very well developed alulae of young Little Auks are noteworthy.

3. Skeletal muscles and heart

The development of the pectoral muscles of young Little Auks is proportional to their body weight. To be sure, the weight of this group of muscles is smaller in them than it is in the adults, but the ratio of their weight to the body weight is nearly identical in these two age groups (Table III). The weight of the hind limb (muscles and skeleton) is in the fledgelings relatively higher than it is in the adult specimens (Table III).

The weight of the heart in young Little Auks is slightly smaller than its weight in the adult birds, whereas its relative value is very high and considerably exceeds the relative weight of the heart specific to adult individuals (Table III).

Table III

Weight of pectoral muscles (P), weight of muscles and skeleton of hind limb (L) and weight of heart (C) of adults (N = 10) and fledgelings (N = 17) of the Little Auk. B — body weight

Measurement	Adults (a)	SD	Fledgelings (f)	SD	$\frac{f}{a} \times 100$ (%)
P (g)	30.41	0.97	20.62	1.42	76.8
L (g)	10.80	0.41	8.43	0.46	77.8
$\frac{P}{B} \times 100$	18.64	0.45	18.76	0.62	100.6
$\frac{L}{B} \times 100$	6.62	0.20	7.65	0.23	115.6
C (g)	2.84	0.67	2.71	0.47	95.4
$\frac{C}{B} \times 100$	1.74	0.38	2.47	0.43	141.9

4. Skeleton

a. Skull. The dimensions of the skull of young Little Auks are smaller than those in the adult birds, its shape and skeletal proportions are, besides, different in these two age groups (Table IV). The skull of the fledgelings is relatively shorter and wider. The development of the splanchnocranium is weaker in them, while the neurocranium is relatively well developed. This indirectly indicates a relatively advanced development of the brain, responsible, among other things, for motor coordination and manners of behaving.

b. Sternum. The sternal keel, lower and shorter in the young Little Auks, has also a smaller ratio of the greatest height to length in them (Table IV). In the young birds the area of the surface for the attachment of the pectoral muscles makes about 70% of this surface in the adults. It is striking that the weight of their sternal muscles also forms 70% of the weight of these muscles in the adult birds (Table III).

c. Skeleton of shoulder girdle and limbs. The global length of the bones of the shoulder girdle of young Little Auks forms about 92% of this length in the adult birds (Table IV). The clavicle, whose length forms 87% of the final length is developed worst and the coracoid, which reaches subfinal dimensions (98.7%) is best developed in the fledgelings of the Little Auk.

The global length of the bones of the wing is similar in both age groups of Little Auks (Table IV). All the segments of the wing are proportionately developed in the fledgelings. The global length of the bones of the hind limb is also similar in these age groups (Table IV). Here, however, the tarsometatarsus is best developed in fledgelings, exceeding in length this segment in the adults (101.4%), while the bones of the middle digit, which reach 96.2% of the final length, are developed worst.

Table IV

Measurements of chosen skeletal elements of adults (for measurements of skull and lenght of sternal kell N = 24, for remaining measurements N = 10) and fledgeling (N = 17) of the Little Auk

	Measurement	Adults (a)	SD	Fledgelings (f)	SD	$\frac{f}{a} \times 100$ (%)
Skull	Greatest length of skull (mm) A	54.51	2.11	45.32	1.60	83.1
	Length of premaxillary (mm) B	31.22	1.27	24.73	1.32	79.2
	B/A	0.57	0.02	0.54	0.02	94.7
	Greatest width of skull (mm) C	21.71	0.59	19.12	0.95	88.0
	C/A	0.40	0.01	0.42	0.01	105.0
	Smallest width of skull (mm) D	10.13	0.47	7.72	0.42	76.2
	D/C	0.46	0.02	0.40	0.01	87.0
Breastbone	Length of keel (mm) E	68.22	2.15	54.43	3.70	79.9
	Greatest hight of keel (mm) F	17.83	0.85	13.12	1.24	73.6
	F/E	0.26	0.01	0.24	0.01	92.3
	Area of surface for attachment of pectoral muscles (sq. cm)	28.22	2.71	19.73	2.69	69.9
Shoulder girdle and limbs	Global length of bones of shoulder girdle (mm)	93.01	2.86	85.80	3.13	92.3
	Global length of bones of wing	126.12	5.65	127.31	5.89	100.9
	Global length of bones of leg	121.50	4.81	120.51	5.01	99.2

IV. DISCUSSION AND CONCLUSIONS

The decisively strongest pressure of the birds of prey (notably *Larus hyperboreus*) falls in the period when the fledgelings of the Little Auk leave the breeding colonies (STEMPNIEWICZ, 1981). As has already been mentioned, the departure to sea of the young birds is their first flight in life. This fact, combined with the relatively little advanced developmental stage of the fledgelings, could theoretically reduce the chances of their survival in this period.

The Little Auks, however, show a number of morphological, ethological and social characters, which must be regarded as adaptations bringing down the mortality rate of the young birds at the time when they leave the breeding colony. These characters are the likeness of the juvenile plumage to the breeding plumage, which makes it hard for the birds of prey to distinguish the young birds, the mass departure of the fledgelings from the colony, and the innate behaviours shown by them when chased by birds of prey (e. g. manoeuvre of diving in the air, hiding or diving in the water; STEMPNIEWICZ, 1981).

The body proportions of young Little Auks described in this paper and compared with the body proportions of adult birds also belong to the morphological and physiological characters of similar significance. The body proportion indices of the fledgelings, analysed from the angle of their locomotor faculty, are equal to and frequently even exceed the analogous indices obtained for the adult specimens. This is, above all, true of the wing area and shape and the size of the heart. The birds that have shorter and wide wings with a well-developed alula and a larger relative area are characterized by a more efficient and diversified type of flight (GLADKOV, 1949; RAIKOV, 1973). Wings exactly like those are observed in the fledgelings of the Little Auk as compared with the adult individuals. The decidedly larger relative weight of the heart of young Little Auks is also of essential importance. It may be supposed that they are fit for more strenuous efforts than are the adult birds.

The young Little Auks owe their advantageous body proportions chiefly to the low body weight. As has been mentioned, the body weight of chicks of the Little Auk, after reaching a maximum on 20th day of life, lowers gradually till the moment of departure. Thus, this pre-fledging loss of weight is responsible to a great extent for the flight-favouring proportions on the day of flight.

Naturally, all the above-decribed indices of body proportions, analysed in the aspect of the locomotor fitness of the young bird, are only theoretical calculation. It should be kept in mind that the young Little Auks, leaving the breeding colony, fly for the first time in life and then have no experience in this respect. The more advantageous body proportions of the young birds make up, at least to a certain degree, for their lack of experience in flight. It may therefore be assumed that the shortening of the nesting period and the departure of fledgelings from the breeding colony at a relatively little advanced developmental stage, beneficial for climatic and environmental reasons (STEMPNIEWICZ, 1980, 1981), do not essentially worsen the chances for the young Little Auks to survive.

Translated into English
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STRESZCZENIE

W latach 1974—1975 prowadzono badania nad biologią okresu lęgowego traczyków lodowych w rejonie Hornsundu, płd.-zach. Spitsbergen (STEMPNIEWICZ, 1981). W roku 1975 zebrano materiał do niniejszej pracy i składało się nań 13 dorosłych i 17 młodych (26-dniowych) traczyków. Celem pracy była analiza porównawcza proporcji w budowie ciała ptaków dorosłych i młodych (opuszczających kolonię lęgową), pod kątem teoretycznych możliwości lokomotorycznych obu tych grup wiekowych. Młode traczyki lodowe, w porównaniu z innymi półzagniazdownikowymi gatunkami alek, przebywają na terenie kolonii lęgowej krócej i opuszczają ją (przeciętnie w wieku 27 dni) w stadium rozwoju mniej zaawansowanym (STEMPNIEWICZ, 1980, 1981). Niniejsza praca miała dać odpowiedź na pytanie, czy wspomniane wyżej cechy nie odbiły się niekorzystnie na stopniu rozwoju aparatu ruchowego, a tym samym na przeżywalności młodych osobników w okresie wylotu z kolonii lęgowej na morze, tym bardziej że lecą one po raz pierwszy w życiu w okresie wzmożonej presji drapieżniczej mew bladych (STEMPNIEWICZ, 1980, 1981).

Wyniki, jakie uzyskano, świadczą o tym, że młode traczyki lodowe opuszczając kolonię lęgową dorównują, a często przewyższają ptaki dorosłe we wskaźnikach proporcji ciała, rozpatrywanych w aspekcie potencjalnych możliwości lokomotorycznych. Młode ptaki mają generalnie mniejsze standardowe wymiary zewnętrzne ciała (tab. I). Krótsze i szersze skrzydła młodych traczyków, z silnie rozwiniętym skrzydełkiem i większą powierzchnią względną (tab. II), umożliwiają im teoretycznie sprawniejszy i bardziej urozmaicony typ lotu. Względny ciężar mięśni piersiowych jest zbliżony u obu grup wiekowych traczyków, natomiast względny ciężar serca jest u młodych ptaków ok. 1,5 razą

wyższy (tab. III). Bezwzględne rozmiary czaszki są u osobników 26-dniowych niższe, przy czym rozwój mózgoczaszki jest u nich bardziej zaawansowany niż rozwój trzewioczaszki (tab. IV). Długość kości pasa barkowego, skrzydła i nogi jest u młodych traczyków zbliżona do wymiarów ostatecznych (tab. IV).

Korzystne proporcje ciała osiągają młode traczyki lodowe w dużej mierze dzięki przedwylotowemu spadkowi ciężaru ciała. Skrócenie okresu gniazdowego piskląt traczyków, korzystne ze względów klimatycznych i siedliskowych, nie wpływa w zasadniczy sposób na obniżenie szans przeżycia młodych ptaków w okresie wylotu z kolonii lęgowej na morze.

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