TABLE II. SKULL MEASUREMENTS WITH PERCENTAGES TO CONDYLO-BASAL LENGTH

No.	*Specimen*	*Absolute dimensions* (mm.)						*Percentage of condylo-basal length*					
		1	2	3	4	5	6	1	2	3	4	5	6
1	Condylo-basal length	361	357	334	370	350	316	100	100	100	100	100	100
2	Rostrum length	179	174	158	196	174	147	49·6	48·7	47·3	53·0	49·7	46·5
3	Rostrum basal width	95	92	80	106	101	96	26·3	25·7	23·9	28·6	28·8	30·4
4	Rostrum width 60 mm. anterior to ant. orb. notches	76	72	62	81	72	58	21·1	25·2	18·6	21·9	20·6	18·3
5	Rostrum width at middle	68	63	56	69	61	51	18·4	17·6	16·8	18·6	17·4	16·1
6	Premaxillae width at same point	33	32·5	27	37	32	27	9·1	9·1	8·1	10·0	9·1	8·5
7	Tip of snout to blowhole	222	214	197	243	222	195	61·5	59·9	59·0	65·7	63·4	61·7
8	Tip of snout to pterygoid	225	222	—	239	216	—	62·3	62·2	—	64·6	61·7	—
9	Preorbital width	174	171	145*	184	168	160	48·2	47·9	43·4	49·7	48·0	50·6
10	Post-orbital width	193	187	158†	203	191	186	53·4	52·4	47·3	54·9	54·6	58·7
11	Orbital width	172	169	142	184	174	160·5	47·6	47·3	42·5	49·7	49·7	51·0
12	Blowhole, width at	53	49	44	57·5	56	58	14·7	13·7	13·2	15·4	16·0	18·3
13	Zygomatic breadth	199	191	160	207	194§	187	55·1	53·4	47·9	55·9	55·4	59·2
14	Greatest width pmx	77	69	66	81	79	ca. 79	21·3	19·3	19·8	21·9	22·6	25·0
15	Width of braincase across parietals	164	168	159	174	165	173	45·4	47·1	47·6	47·0	47·1	54·7
16	Number of teeth upper R	29	33	31	26	30	—	—	—	—	—	—	—
17	Number of teeth upper L	30	—	31	25	30	—	—	—	—	—	—	—
18	Length of tooth row upper R	143	154	128	151	146	—	39·6	43·1	38·3	40·8	—	—
19	Length of tooth row upper L	142·5	154	131	152	—	—	39·5	43·1	39·2	41·1	41·7	—
20	Hinder end of upper tooth row to tip of pmx R	155	154	137	165	—	129	42·9	43·1	41·0	44·6	—	40·8
21	Hinder end of upper tooth row to tip of pmx L	154	152	136	167	156	128	42·7	42·6	40·7	44·8	44·6	40·5
22	Number of teeth lower R	27	28+	—	30	29	—	—	—	—	—	—	—
23	Number of teeth lower L	27	29+	—	30	30	—	—	—	—	—	—	—
24	Length of lower tooth row R	140	136	—	165	154	—	38·8	38·1	—	44·6	44·0	—
25	Length of lower tooth row L	140	136	—	163	151	—	38·8	38·1	—	44·1	43·1	—
26	Hinder end of lower tooth row to tip of mandible R	150	144	—	167	156	—	41·6	40·3	—	44·8	44·6	—
27	Hinder end of lower tooth row to tip of mandible L	148	145	—	164	153	—	40·9	40·6	—	44·3	43·7	—
28	Mandible length	296	292	—	306	288	—	81·9	81·8	—	82·7	82·3	—
29	Coronoid height	71	68	—	69	69	—	19·6	19·0	—	18·6	19·7	—
30	Length of symphysis	36	35	—	44	32	—	9·9	9·8	—	11·9	9·1	—
31	Post-temporal length	76	76	71‡	69	67	68	21·1	21·3	21·3	18·6	19·1	21·5
32	Post-temporal height	50	51	50	37	31	33	13·9	18·0	15·0	10·0	8·9	10·4
33	¾ rostrum length—width at	50	45	39·5	50	43	—	13·9	12·6	11·8	13·5	12·3	—
34	Cranial height	117	118	109	116	116	111	32·4	33·1	32·6	31·3	33·1	35·1
35	Cranial length internal	135	137	135	121	124	118	37·4	38·4	40·5	32·7	35·4	37·3

* Preorbital broken, width estimated.
† Post-orbital broken, width estimated.
‡ Zygomatic process incomplete, width estimated.
§ Right zygomatic incomplete, estimated on half skull width.

The numbers in the first column refer to Fig. 1.

[*face page 29*

SKULL OF *Lagenorhynchus cruciger* FROM LIVINGSTON ISLAND, SOUTH SHETLAND ISLANDS

By F. C. FRASER* *and* B. A. NOBLE†

ABSTRACT. A comparison of skulls of *Lagenorhynchus australis* and *L. cruciger* provides osteological criteria distinguishing these two as separate species. A skull found on the beach at Livingston Island, South Shetland Islands, is identified as *L. cruciger*.

IN a paper included in *Whales, dolphins and porpoises*, Fraser (1966) drew attention to an earlier paper by Scheffer and Rice (1963) in which *Lagenorhynchus obscurus* (Gray 1828) and *L. australis* (Peale 1848) are included in the synonymy of *L. cruciger* (Quoy and Gaimard 1824). This synonymy was based, at least in part, on Bierman and Slijper (1947). It is repeated in Hershkovitz (1966). In Fraser's (1966) paper the distinctiveness of the skull of *L. obscurus* from either *L. cruciger* or *L. australis* was demonstrated, but at that time no sufficiently trenchant characters were observed that would distinguish the skulls of *L. cruciger* and *L. australis* from each other, although the pigmentation pattern of the two animals was shown to be different. A re-examination of the available specimens of *L. cruciger* and *L. australis* became necessary in connection with the identification of a skull from Livingston Island, South Shetland Islands.

The specimens examined are listed in Table I.

TABLE I

	Species	*British Museum (Nat. Hist.) register number*	*Locality*
1	*Lagenorhynchus australis*	1944.11.30.1	Porpoise Point, Falkland Islands
2	*L. australis*	1961.6.12.1	No history
3	*L. australis*	1952.6.20.1	Carcass Island, West Falkland
4	*L. cruciger* ♀	1960.8.24.1	Lat. 56°20′S., long. 40°09′E.
5	*L. cruciger*	1849.5.25.3–935a	Pacific Ocean. Type of *Electra clancula* (Gray 1846)
6	*L. cruciger*	1967.7.24.1	Livingston Island, South Shetland Islands

Standard skull measurements are given in Table II.

DISCUSSION

The proportions of skull dimensions to condylo-basal length are shown in Fig. 1. In the graph, the skull measurements have been re-arranged to bring dimensions of the same region of the skull in proximity to one another. As the skull grows, certain dimensions increase disproportionately to condylo-basal length. In addition, the rostrum length, which is included in the condylo-basal length, does itself grow disproportionately. These qualifications make linear comparison only approximate when specimens of different ages are involved, but somewhat more concise when the sample is composed of adults.

From Fig. 1 the skull breadth proportions of the Livingston Island specimen appear anomalous in relation to the proportions of the other specimens. The absolute rostral length suggests that the animal was juvenile, but the orbital proportions are in excess even of an adult, whilst these latter proportions in the juvenile *L. australis* skull are situated as might be expected in relation to those of the adult skulls. The Livingston Island skull is a beach specimen. It shows general indications of wear by erosion so that areas of the rostrum, where

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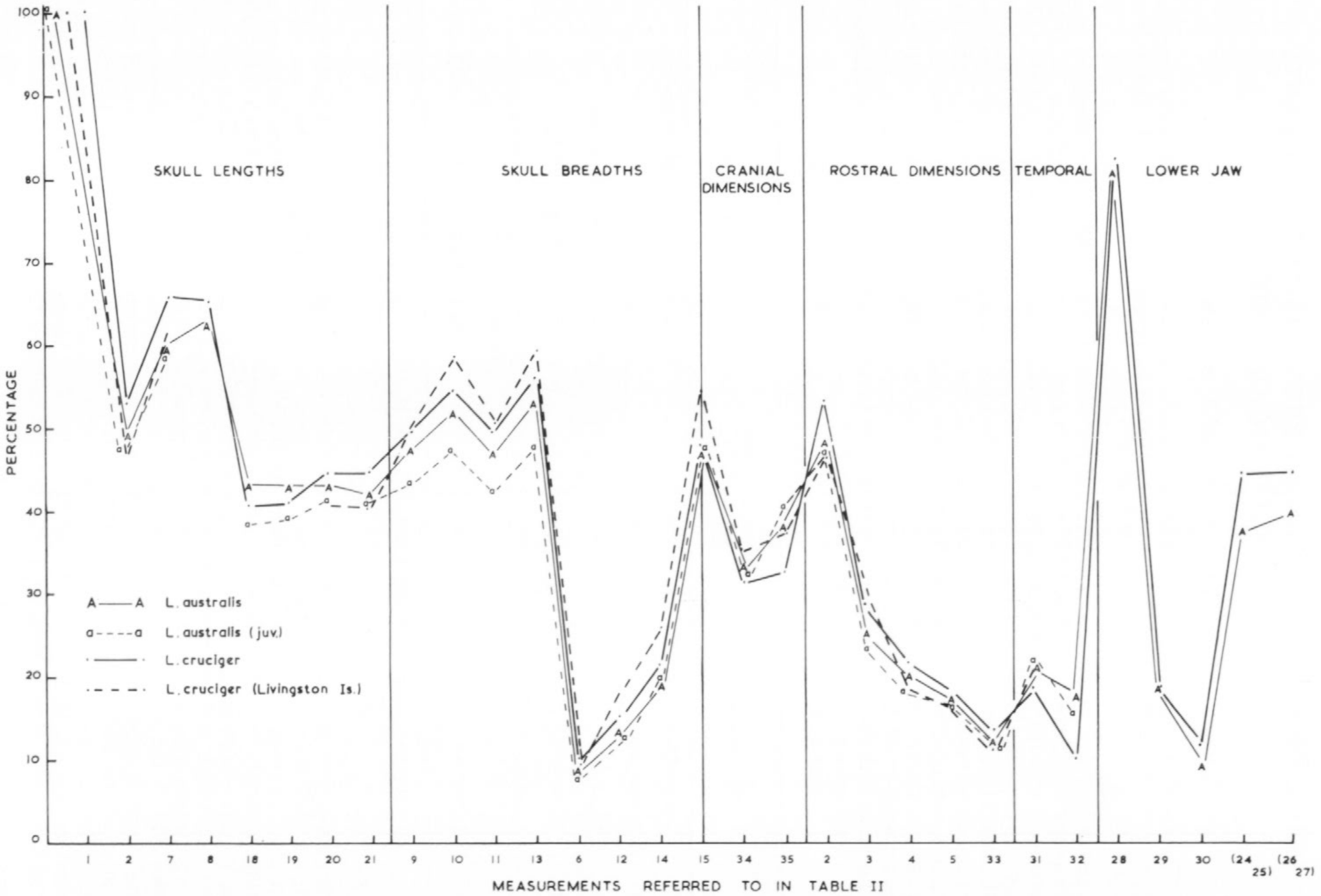

Fig. 1. Graph of skull proportions of *L. australis*, *L. cruciger* and the Livingston Island specimen, expressed as percentages of condylo-basal length.

the surface of the compact bone would normally be present, are in fact roughened. The rostral maxillary region has this roughened appearance which extends some distance above the preorbital area. The posterior margins of the maxillary bones are extensively damaged (Fig. 2A). Although the tip of the rostrum has a superficially normal appearance, the tips of the left premaxilla and maxilla are longer than the right.

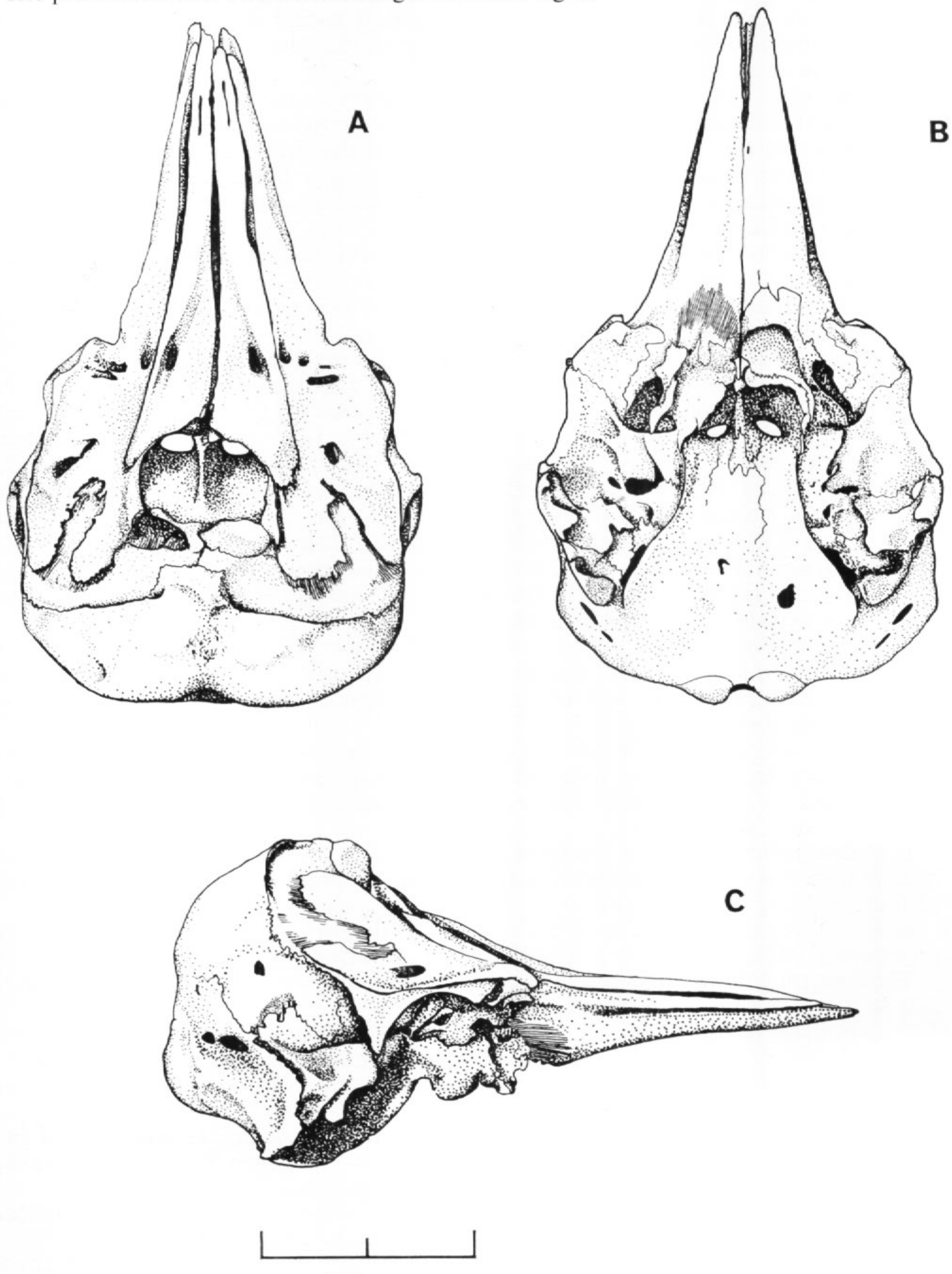

Fig. 2. Livingston Island specimen; orthographic projections of dorsal (A), ventral (B) and lateral (C) aspects.

Posteriorly, the margins of the alveolar groove are orientated to accommodate teeth set therein in the normal way. But, from about the middle of the rostrum to the tip, the groove is increasingly orientated laterally instead of ventrally. This is the situation that would be produced, were the outer edges of the rostrum to be eroded, because normally the outer margin of the tooth groove would overhang the inner.

This condition of the rostrum provides reasonable explanation for the rostral proportions shown in Fig. 1 conforming to those of a juvenile *L. australis*, while the orbital and zygomatic proportions are in excess of those of adult specimens.

With the impression that the rostrum of the Livingston Island specimen may have been truncated by erosive action, a graph was prepared in which the parietal width was used as base reference (Table III; Fig. 3). The graph shows that the skull-length proportions of the Livingston Island specimen are much below those of the juvenile *L. australis*. The breadth proportions, in contrast, are in reasonable relation to both the juvenile *L. australis*, and the adult *L. cruciger* and *L. australis*.

The conclusion from these proportions is that the rostral length of the Livingston Island specimen is the result of mechanical action on the beach.

The Livingston Island specimen must be regarded as being more nearly adult than the rostral proportions would indicate.

In the comparison of the available specimens, the following skull features were noted:

i. In general, it will be seen from Fig. 1 and Table II that the proportions of *L. australis* and *L. cruciger* are very similar, but it has to be appreciated that the smaller the dimension, the less is any difference proportional to the total length likely to obtrude. Nevertheless, even in the proportions shown in Fig. 1, the post-temporal dimensions indicate a marked difference between *L. australis* and *L. cruciger*, which is more patently shown in Fig. 3 where the relation of these dimensions is to a smaller base line. In fact, the differences are more readily appreciated visually than they are graphically (Fig. 4). The post-temporal fossa of *L. cruciger* is smaller than that of *L. australis*. As shown in Fig. 4, the Livingston Island specimen, in this character, is very closely comparable with *L. cruciger* and different from *L. australis*.

   The orientation of the longer axis of the post-temporal fossa, in relation to the long axis of the skull, makes a greater angle with the horizontal in *L. cruciger* than does that of *L. australis* (Fig. 5). In this respect, the Livingston Island specimen is more like *L. cruciger* than *L. australis*.

ii. In their consideration of the pterygoid sinuses of *Lagenorhynchus*, Fraser and Purves (1960) were able to show the different extent of development of the pterygoid lobes in *L. albirostris*, *L. acutus* and *L. obscurus*, the last species, a southern form, having the maximum sinus development.

   L. australis shows a similar extent of development of the pterygoid lobes to that noted in *L. obscurus*. As in the latter species, the sinus of the preorbital lobe is well defined and projects mesially above the orbitosphenoid (Fig. 6a, a′).

   In *L. cruciger* the sinus of the preorbital lobe is shallow, ill defined and is without any pronounced mesial projection above the orbitosphenoid (Fig. 6b, b′).

   The foregoing description of *L. cruciger* fits the Livingston Island specimen (Figs. 2B and 6c′).

iii. The zygomatic processes of the squamosal of *L. australis* and *L. cruciger* are conspicuously different in size: that of the former being smaller (Fig. 4A). The squamosal of the Livingston Island specimen has proportions comparable with those of *L. cruciger* (Fig. 4C).

iv. In the pre-narial region, the margins of the pre-narial triangle are well defined in *L. cruciger* by a gutter on each side extending some way posteriorly from the premaxillary foramen, and anteriorly almost to the apex of the triangle.

   In *L. australis*, the posterior part of each gutter is distinct to an extent comparable with that of *L. cruciger*, but anteriorly it is very shallow and ill defined (Fig. 7).

   Present in both species is a meso-posteriorly reflecting groove stemming from the anterior part of the gutter, which is more conspicuous in *L. australis* because of the ill-defined main gutter in this region.

TABLE III. PERCENTAGE PROPORTIONS OF SKULL MEASUREMENTS TO PARIETAL WIDTH

No.		*Percentage of parietal width*					
	Specimen	1	2	3	4	5	6
1	Condylo-basal length	220·0	212·5	210·0	212·6	212·1	182·7
2	Rostrum length	109·1	103·5	99·4	112·7	105·4	85·0
3	Rostrum basal width	57·9	54·8	50·3	60·9	61·2	55·0
4	Rostrum width 60 mm. anterior to ant. orb. notches	46·3	42·8	39·0	46·6	43·6	33·5
5	Rostrum width at middle	41·5	37·5	35·2	39·6	37·0	29·5
6	Premaxillae width at same point	20·1	19·3	17·2	21·3	19·4	15·8
7	Tip of snout to blowhole	135·4	127·4	123·9	139·6	134·5	112·7
8	Tip of snout to pterygoid	137·2	132·1	—	137·7	130·9	—
9	Preorbital width	106·0	101·8	91·2	105·8	101·8	92·6
10	Post-orbital width	117·7	111·3	99·4	116·7	115·7	107·5
11	Orbital width	104·9	100·6	89·3	105·8	105·4	92·8
12	Blowhole, width at	32·3	29·2	27·7	32·7	33·9	33·5
13	Zygomatic breadth	121·3	113·7	100·4	119·0	117·6	108·1
14	Greatest width pmx	47·0	41·1	41·5	46·6	47·9	45·6
15	Width of brain case across parietals	100	100	100	100	100	100
16	Number of teeth upper R	—	—	—	—	—	—
17	Number of teeth upper L	—	—	—	—	—	—
18	Length of tooth row upper R	87·2	91·7	80·5	86·8	88·5	—
19	Length of tooth row upper L	86·9	91·7	82·4	87·4	94·5	—
20	Hinder end of upper tooth row to tip of pmx R	94·5	91·7	86·2	94·8	—	74·6
21	Hinder end of upper tooth row to tip of pmx L	93·9	90·5	85·2	95·3	—	74·0
22	Number of teeth lower R	—	—	—	—	—	—
23	Number of teeth lower L	—	—	—	—	—	—
24	Length of lower tooth row R	85·4	80·9	—	94·8	93·3	—
25	Length of lower tooth row L	85·4	80·9	—	93·7	91·5	—
26	Hinder end of lower tooth row to tip of mandible R	91·5	85·7	—	95·3	94·5	—
27	Hinder end of lower tooth row to tip of mandible L	92·4	86·3	—	94·3	92·7	—
28	Mandible length	180·5	173·8	—	175·9	174·6	—
29	Coronoid height	43·3	40·5	—	39·7	41·8	—
30	Length of symphysis	21·9	20·8	—	25·3	19·4	—
31	Post-temporal length	46·3	45·2	44·7	39·7	40·6	39·3
32	Post-temporal height	29·8	30·4	31·5	21·3	20·4	19·6
33	$\frac{3}{4}$ rostrum length—width at	29·8	26·8	24·8	28·7	26·1	—
34	Cranial height	71·4	70·2	68·6	66·7	70·3	64·2
35	Cranial length internal	82·3	81·5	84·9	69·5	75·1	68·2

The numbers in the first column refer to Fig. 3.

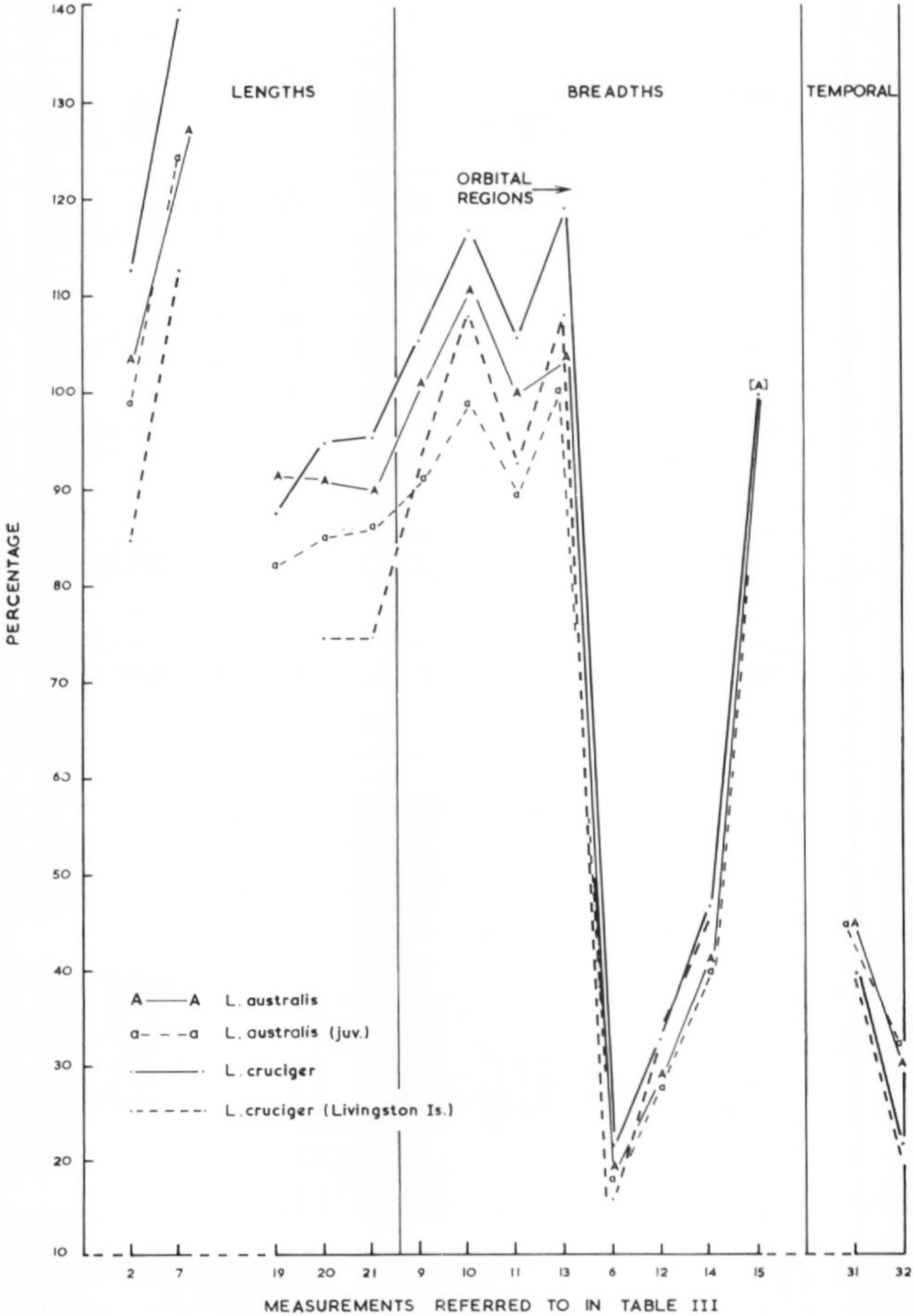

Fig. 3. Graph of skull proportions of *L. australis*, *L. cruciger* and the Livingston Island specimen, expressed as percentages of parietal width.

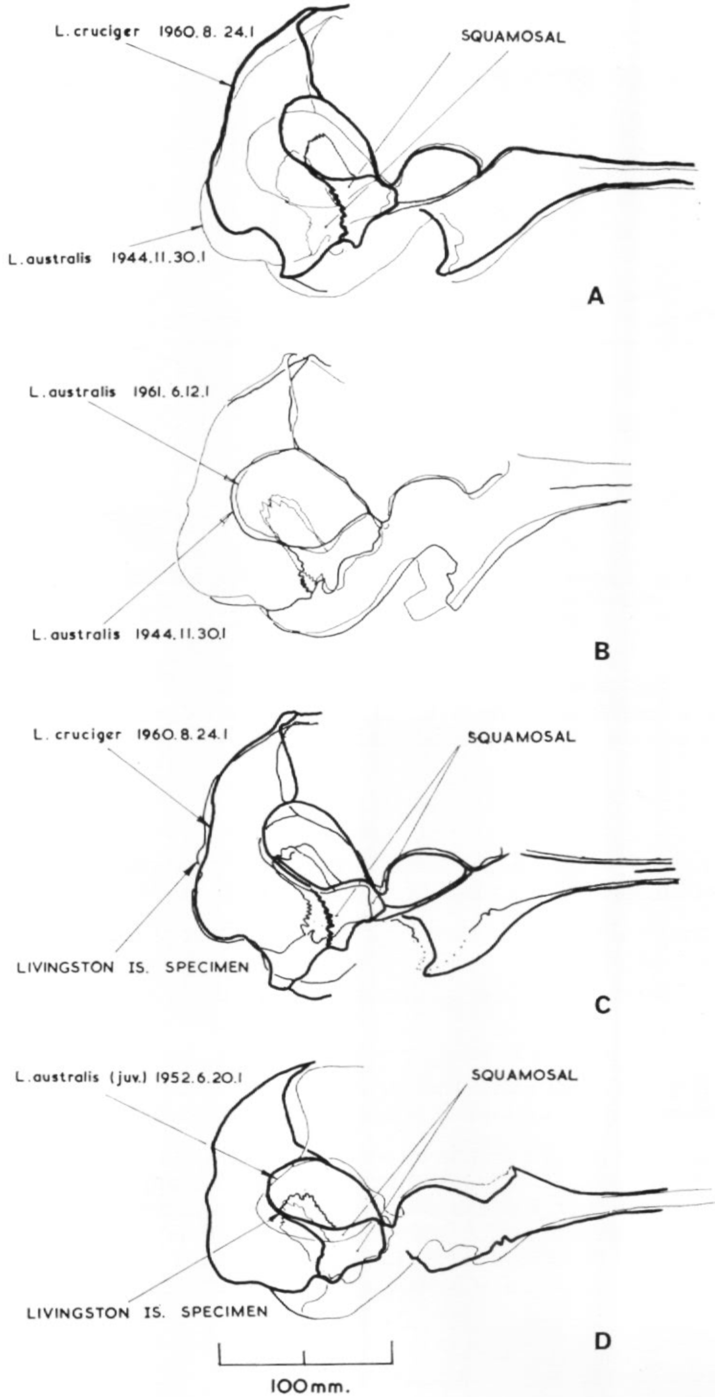

Fig. 4. Temporal region.
A. Comparison of *L. australis* and *L. cruciger*.
B. Two *L. australis*.
C. *L. cruciger* and the Livingston Island specimen.
D. *L. australis* juvenile and the Livingston Island specimen.
Orthographic projections.

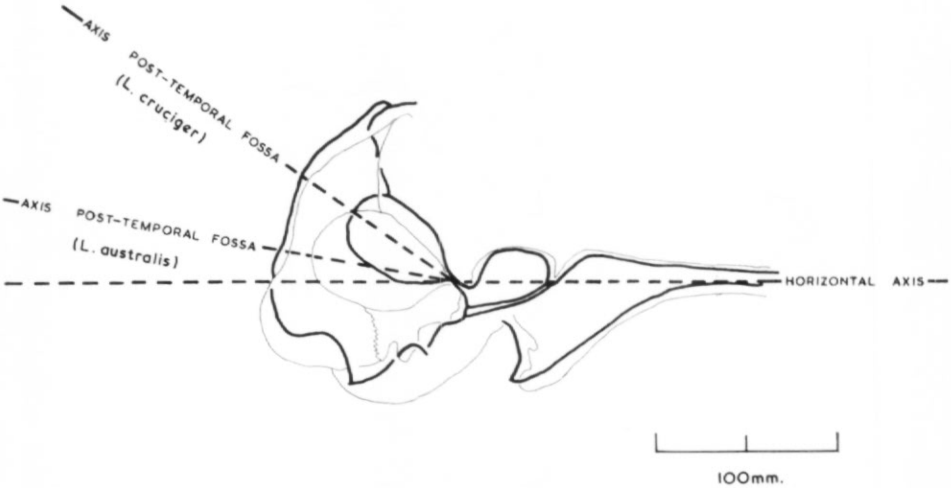

Fig. 5. Orientation of post-temporal fossa; superimposed orthographic projections of the temporal region of *L. australis* and *L. cruciger*.

In the Livingston Island specimen, the anterior, as well as the posterior part of each gutter is well developed, as in *L. cruciger*, but the reflected grooves are not distinguishable because of erosion of the pre-narial triangle (Fig. 2A).

Conclusions

From the foregoing observations, it has been shown that the skull of *Lagenorhynchus australis* can be distinguished from that of *L. cruciger* by the following criteria:

i. The post-temporal fossa of *L. australis* is larger than that of *L. cruciger*, and its long axis is differently orientated.

ii. The sinus of the preorbital lobe of the pterygoid air sac of *L. australis* is larger than that of *L. cruciger*.

iii. The zygomatic process of *L. cruciger* is more massive than that of *L. australis*.

iv. The guttering in the pre-narial triangle of *L. cruciger* extends nearly to the apex of the triangle, whereas in *L. australis* it is obscure anterior to the premaxillary foramen.

These skull characters provide criteria by which distinction can be made between *L. australis* and *L. cruciger*. They combine with differences in the external appearance of these two forms already demonstrated (Fraser, 1966) to justify recognition of *L. australis* as specifically distinct from *L. cruciger*. The relegation of *L. australis* to the synonymy of *L. cruciger* is considered by the present writers to be unwarranted. On application of the foregoing osteological criteria to the Livingston Island specimen, it is shown to be a member of the species *Lagenorhynchus cruciger*.

Acknowledgements

The authors wish to express their thanks to the British Antarctic Survey for making the Livingston Island specimen available for examination, and to Mr. Fergus O'Gorman for collecting this specimen and for arranging its subsequent transportation to London.

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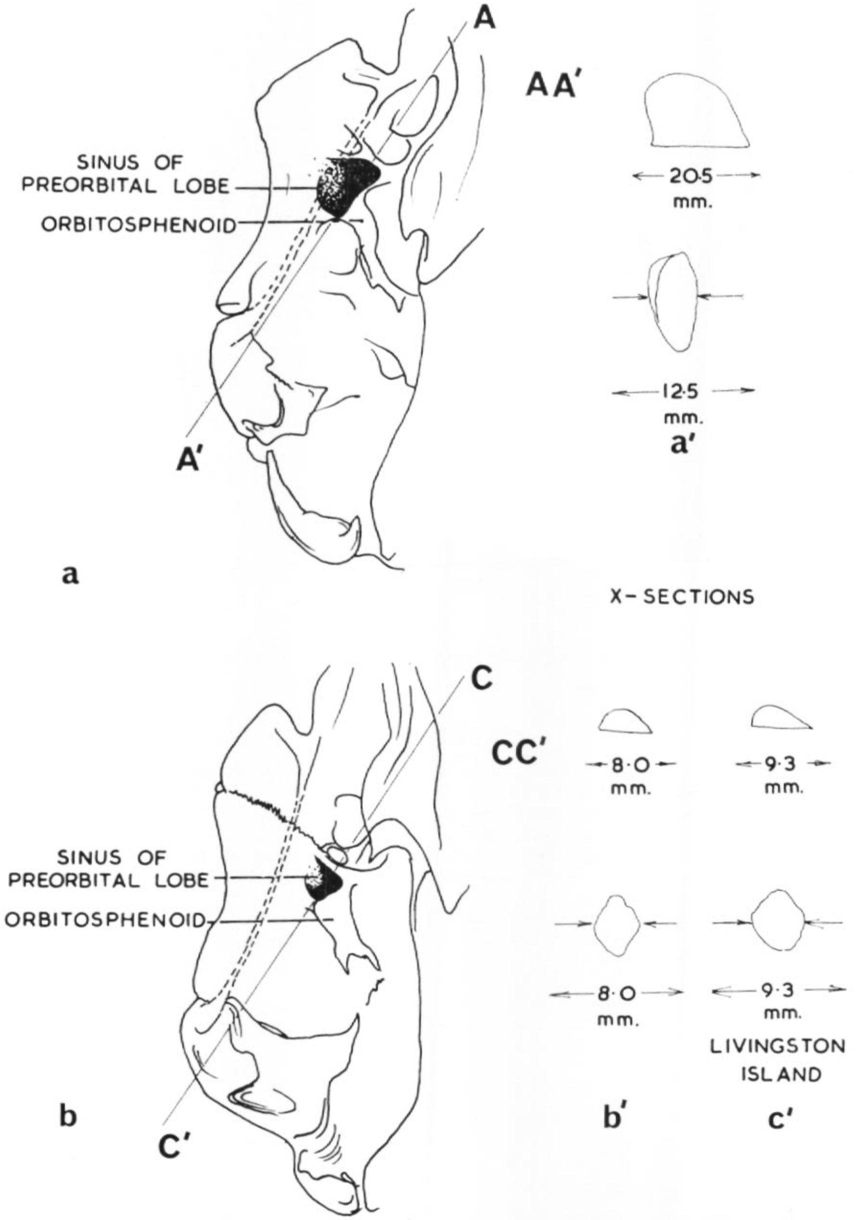

Fig. 6. Sinus of preorbital lobe of pterygoid air sac: ventral view of the orbital region of *L. australis* (a) and *L. cruciger* (b) with longitudinal (AA′, CC′) and transverse sections of the sinus, with comparable sections of the Livingston Island specimen.

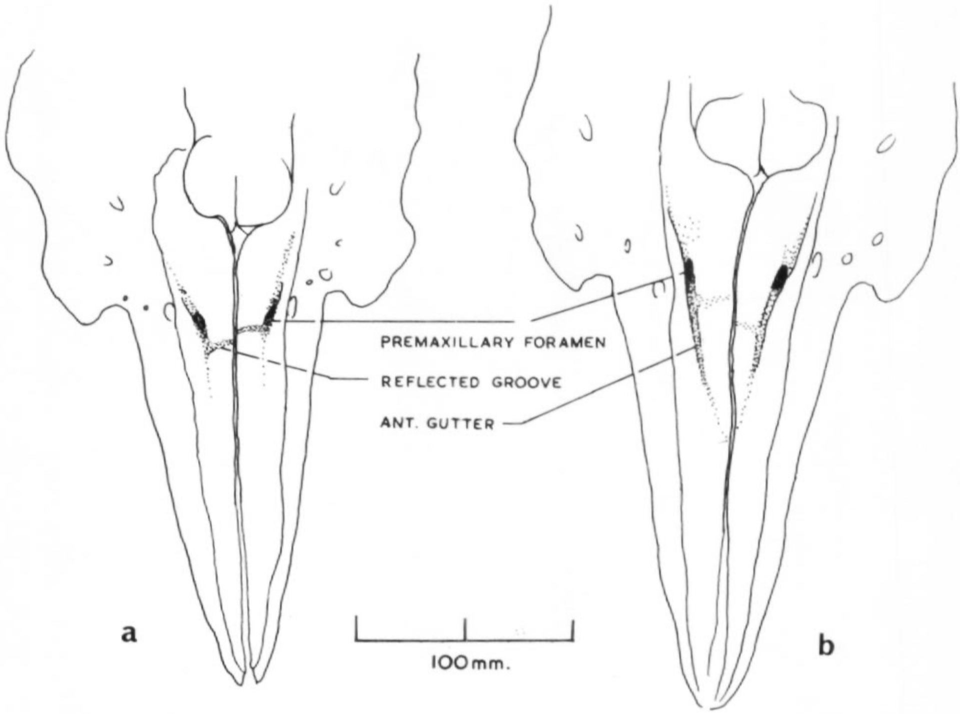

Fig. 7. Prenarial region of *L. australis* (a) and *L. cruciger* (b). Orthographic projections.

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