BRYDE'S WHALE FROM THE COAST OF JAPAN

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INTRODUCTION

It was not until 1910 that a whale known by Japanese as the 'Iwashi Kujira' (Sardine Whale) was discovered by Andrews that it was none other than the Pacific counterpart of *Balaenoptera borealis* Lesson. He remained in Japan during the spring and summer of 1910, and about 75 specimens of the 'Iwashi Kujira' came under his observation and it was thus possible to him to make an extensive study of the life history, external anatomy and individual variation of the species. But, unfortunately he could not discover the existence of another species of whale, the Bryde's whale, which is also generally known as the 'Iwashi Kujira'.

The Bryde's whale, *Balaenoptera brydei* Olsen, was firstly described by Olsen in a Norwegian newspaper 'Tidens Tegn' dated November 12, 1912. In the following year a full description of the external characters and biology of this species was given by the same author (1913). Andrews (1916) in his monograph on sei whale, based on the material gathered during his stay in Japan in 1910, treats briefly *B. brydei* under the heading of 'Doubtful Species Related to *B. borealis*' and thought that this species, although very similar in proportions and color and closely allied to *B. borealis*, is probably distinct from that species. He regretted that no osteological details are supplied in Mr. Olsen's account. It was in 1931 that a detailed description of the skeleton by Lönnberg appeared and some distinctions in the skeleton were noted. Thus it seemed probable that the two species are distinct, though the question was not regarded as finally settled (Mackintosh, 1947). Of the distribution of *B. brydei* it has long been thought that it occurs only in the South African waters and rarely elsewhere.

On the 18th June 1871 a whale stranded in a creek named Thaybyoo Choung near Sittang river which runs into the Gulf of Martaban, Burma. This whale was examined by Anderson (1878) and was named *Balaenoptera edeni*, in recognition of the Hon'ble Ashley Eden, then Chief Commissioner of British Burma, having been the means of saving this whale to science. Andrews (1916) treats also this species in his monograph on sei whale and thought that *B. edeni* is either identical with, or closely allied to *B. borealis* and he describes that "It is highly desirable that this skeleton be re-examined in the light of present knowledge of the large Cetacea, but until this is done, or other specimens have been

obtained from the same waters, it appears to me that it is wisest to leave *Balaenoptera edeni* as a very doubtfully established species". In 1918 he examined the skeleton of *B. edeni* in the Calcutta Museum and came to a conclusion that it was difficult to believe that the differences between the skeletons of *B. edeni* and *B. borealis* were individual and he mentioned the possibility that *B. edeni* was identical with *B. brydei*, though at that time only the external characters of *B. brydei* were known.

A rorqual was cast ashore on the coast of Pulu Sugi, one of the smaller islands of the Rhio Archipelago between Singapore and the Sumatran coast in July 1936. The specimen was saved and after cleaning it was sent to the Rijksmuseum van Natuurlijke Historie, Leiden. Junge (1950) studied this skeleton in detail, as well as the skeletons of *B. brydei* from Saldanha Bay, South Africa and those of *B. edeni* kept in the British Museum, the South African Museum, and in the Calcutta Museum. After comparing these skeletons he came to a conclusion that we can consider *edeni* and *brydei* conspecific, which makes the name *Balaenoptera brydei* Olsen a synonym of *Balaenoptera edeni* Anderson and the species occurs in South African waters as well as in the waters of South-eastern Asia.

In 1950 (a), while engaging in an analysis of weights of various parts of the body of the 'Iwashi Kujira' taken in the waters around Japan, I noticed that there is a striking difference in weight, especially in the weight of blubber between those taken in the Bonin Island's waters and those from the north-eastern part of Honshu (Japan proper). Also in the average body length of maturity they showed some difference, those from the Bonin Island's waters being shorter by 2–3 feet (1950, b). I thought, for the time being, there might exist two local races of sei whale in the adjacent waters of Japan, viz. southern and northern types, the former being frequent in the waters around Bonin Islands. After studying the body proportions and baleen plates of the two types, cooperated by Messrs. Nishimoto and Fujino, I came to a conclusion that the southern type is more closely related to the Bryde's whale, *Balaenoptera brydei*, than to the ordinary sei whale, *B. borealis*, though the northern type hardly differ from *B. borealis* (1952). Further studies on external characters led to the conclusion that the southern type is identical with *B. brydei* (=*edeni*), while the northern type is nothing but *B. borealis* (Omura & Fujino, 1954). Movements of these two species were studied in relation to the water temperature (Omura & Nemoto, 1955). Omura & Fujino (1954), however, raised a question as to the number of the vertebrae of *B. edeni*. Total numbers of vertebrae of *B. brydei* and *B. edeni* are reported as 52 (or perhaps 53) by

Anderson (1878), Lönnberg (1931), and Junge (1950), while according to our investigations at whaling landstations on fresh bones of our Bryde's whales they number 54–55. This problem had been remained unsolved until our osteological study being concluded.

In 1953 a skeleton of *B. edeni* was preserved at Ayukawa landstation in Miyagi prefecture and in the following year it was sent to the National Science Museum in Tokyo, where it was mounted. But unfortunately this skeleton was incomplete and its vertebrae were mixed with some of vertebrae of other species, which was sent also from the same landstation.

It was not until 1958 that the second skeleton of *B. edeni* was preserved at Ayukawa. This skeleton was nearly perfect when fresh, but most of the left ribs, right scapula and left flipper were lost during the course of preparation as sample. The fresh bones had been burried in sand of beach for removal of soft parts attached and oil contained for about five months, during which period a heavy storm came and washed these above listed bones away. But other bones have been saved in good condition and they are available for the osteological study.

During a visit in 1958 to the Rijksmuseum van Natuurlijke Historie, Leiden I was able to examine the Pulu Sugi specimen of *B. edeni*, by courtesy of Dr. G. C. A. Junge. He also gave me all the help I needed. I am much indebted to Dr. M. Nishiwaki and Mr. T. Ichihara for their co-operation in examining and taking photographs of the skeleton of *B. edeni* at Ayukawa. Messrs. S. Aizawa and N. Kimura of the Whale Museum at Ayukawa undertook the laborious work of making a sample of skeleton, which was presented in fresh by the kindness of the Nippon Kinkai Hogei K. K. My sincere thanks are due to my colleagues Messrs. S. Nishimoto, K. Fujino, and T. Nemoto in concluding my work on identification of the Bryde's whale from the coast of Japan.

OSTEOLOGY

On 15th July 1958 a Bryde's whale was taken by a whale catcher belonging to the Nippon Kinkai Hogei K.K at 37°15′ N and 144°40′ E. The surface water temperature of the position was recorded as 22.6°C. This whale, female of 45 feet in length, was treated on the following day at the Ayukawa landstation and was proved that its skeleton had no damage by grenades and harpoon. Accordingly it was decided to preserve the skeleton as specimen and all of the fresh bones were burried in sand of nearby beach, except some small caudal vertebrae which were kept in a jar contained with water.

On 25th November 1958 these bones were digged out from sand and

after cleaning they were examined by me assisted by Dr. M. Nishiwaki and Mr. T. Ichihara of the Whales Research Institute. Since then this skeleton has been kept in the Whale Museum at Ayukawa.

Skull (Plates I–III). The most striking feature of the skull of *B. edeni* is the flat and straight forward pointing shape of the rostrum. Anderson (1878) describes that the leading characteristics of the skull, as compared with the skulls of known *Balaenoptera*, are the great length of the maxillary portion and the little downward shelving of the upper surface of the maxillaries. Junge (l. c., p. 4) reports that in his Pulu Sugi specimen the premaxillaries, especially their posterior ends, are sunk in between the maxillaries cause the flat appearance, when the skull is viewed laterally. Lönnberg also notes to the fact that the rostrum of *B. brydei* is flat and straight as compared with skulls of *borealis*. Junge (l. c., p. 5), however, points out that there is some variation in *brydei*. He describes that the skull of *brydei* in the British Museum has a rostrum of more curved to the rostral side and in this specimen and in Lönnberg's the maxillaries are also slightly more curved to the lateral side.

TABLE 1. SELECTED PROPORTIONAL SKULL MEASUREMENTS OF *borealis*, *brydei* AND *edeni* (After Junge 1950)

	borealis 6 specimens	*brydei* 3 specimens	*edeni* 3 specimens
Length of skull in mm	2,080–3,900	2,770–3,300	2,920–3,160
From nasals to tip of premaxillaries[1)]	62.2–72.0%	65.6–81 %	71.2–75 %
Breadth of rostrum basally[1)]	26.5–30.7%	32 –45 %	26.2–28.1%
Breadth of rostrum at its middle[1)]	16.6–18.7%	20 –21.5%	19.6–27.8%

1) Expressed as percentage of the skull length.

Our Ayukawa specimen resembles to the skull of *brydei* in the British Museum in this respect. It's rostrum is more curved downwards than the Thaybyoo Choung and Pulu Sugi specimens of *edeni* reported by Anderson (1878) and Junge (1950), but in lesser extent when compared with *borealis* (Plate XLII of Andrews 1916). Also in the Ayukawa specimen major parts of the premaxillaries are sunk in between the maxillaries, but their anterior ends rise slightly above them. These are caused by more downward curving of the maxillaries. The ventral sides of the outer edge of the maxillaries are slightly bent down in both ends, whereas in the Pulu Sugi specimen practically horizontal anteriorly. The undersides of the maxillaries are rather straight anteriorly and more curved posteriorly. In these characters it quite agrees with the specimen of *brydei* in the British Museum (Plate VI of Junge 1950).

The another point which Anderson (1878) describes as the leading characteristics of the skull is the great length of the maxillary portion.

Junge (l. c., p. 7) gives a table of selected proportional measurements of skulls of *borealis*, *brydei* and *ededi*, which is summarized in Table 1.

The proportional distances from nasals to tip of premaxillaries of *borealis*, *brydei* and *edeni* are 62.2–72.0%, 65.6–81% and 71.2–75% respectively and he concludes that the range of rostrum length is longer in *brydei* and *edeni* than in *borealis*, though there is overlapping. Lönnberg (1931) remarks, however, that the rostrum of Bryde's whale compared with that of a sei whale is comparatively shorter and broader.

In Table 2 are shown the skull measurements of the Ayukawa specimen of *edeni*, compared with those of *borealis*, which was taken on 3rd July 1957 and processed at Ayukawa on the following day. This skeleton of *borealis* was later sent to the Staatliches Museum für Naturkunde, Stuttgart, Germany. In this Ayukawa specimen of *edeni* the proportional distance from nasals to tip of premaxillaries is 70.1% of the length of the skull, which falls within the overlapping range of *borealis* and *brydei* and a little shorter than *edeni* in Table 1. I was not able to measure the same length in the specimen of *borealis*, because the nasals were missed in this specimen. However, in the specimen of Andrews (1916) from the coast of Japan this length is only 62.2% of the length of the skull, measured by Junge from the plate. Shorter proportional distance in this portion in *borealis* than *edeni* is anticipated also in the specimens from the coast of Japan.

On the other hand the length of beak, measured from its base, is 64.1% of the skull length in *edeni*, whereas in *borealis* 67.0%. Our specimen of *edeni*, therefore, supports the remarks of Lönnberg too. The proportional length of premaxillaries is also shorter in *edeni*, though the length of maxillaries is practically similar with *borealis*. The breadth of beak at its base is similar, when reduced in percentage against length of skull, but broader in *edeni* at its middle. This means the rostrum of *borealis* is more tapering distally. The outer edges of maxillaries are more curved in *edeni* (Plate I), whereas in *borealis* nearly straight. This gives an impression that in *edeni* the rostrum is comparatively shorter and broader than *borealis*.

Junge (l. c., p. 8) stresses the fact that in *brydei* and *edeni* the nasal processes of the maxillaries are narrower than in *borealis*. According to him the breadth at the anterior border of the nasals is less than 1/5 of their length and even about 1/7 in a specimen of *brydei*, whereas in *borealis* about 1/3 or less. In the Ayukawa specimen this value is about 1/4. This means that in this specimen the nasal processes of the maxillaries are shorter than in any specimens of *edeni* and *brydei*, but still longer than *borealis*. This is also observed if the photograph of Andrews (l. c., Plate XLI, Fig. 1) is compared with Plate I, Fig. 1, though

TABLE 2. SKULL MEASUREMENTS OF *edeni* FROM THE COAST OF JAPAN, COMPARED WITH *borealis*

Measurements	*B. edeni* Ayukawa, 45 ft. ♀			*B. borealis* Ayukawa, 43 ft. ♀		
	in mm	% of length	% of breadth	in mm	% of length	% of breadth
Length of skull (straight)	3,480	**100.0**	215.5	3,062	**100.0**	229.4
〃 〃 beak	3,230	64.1	138.1	2,052	67.0	153.7
〃 〃 premaxillary (straight)	2,640	75.9	163.5	2,433	79.5	182.2
〃 〃 maxillary along upper surface R	2,495	71.7	154.5	2,163	70.6	162.0
〃 〃 maxillary along upper surface L	2,500	71.8	154.8	2,145	70.1	160.7
Tip of premax. to post. end of maxillaries	2,670	76.7	165.3	—	—	—
〃 〃 〃 〃 vertex	2,695	77.4	166.9	—	—	—
〃 〃 〃 〃 tip of nasals (mesial)	2,440	70.1	151.1	—	—	—
〃 〃 〃 〃 ant. end of palatines	2,445	70.3	151.4	—	—	—
〃 〃 〃 〃 post. end of palatines (mesial)	2,909	83.6	180.1	—	—	—
〃 〃 〃 〃 post. end of pterygoids	3,225	92.7	199.7	2,795	91.3	209.4
〃 〃 〃 〃 ant. end of maxillaries	183	5.3	11.3	—	—	—
〃 〃 〃 〃 ant. end of vomer	439	12.6	27.2	—	—	—
Length of supraoccipital from foramen magnum	835	24.0	51.7	768	25.1	57.5
Greatest breadth of skull (squamosal)	1,615	46.4	**100.0**	1,335	43.6	**100.0**
Breadth of skull (frontal)	1,540	44.3	95.4	1,266	41.3	94.8
〃 〃 〃 (maxillary)	1,445	41.5	89.5	1,144	37.4	85.7
〃 〃 beak at base	955	27.4	59.1	844	27.6	63.2
〃 〃 〃 〃 middle	645	18.5	39.9	507	16.6	38.0

Breadth across premaxillaries, greatest		330	9.5	20.4	—	—	—
〃 〃 〃 at base of beak		302	8.7	18.7	255	8.3	19.1
〃 〃 〃 at middle of beak		219	6.3	13.6	217	7.1	16.3
Length of nasals mesially		198	5.7	12.3	* —	—	—
〃 〃 〃 laterally		266	7.6	16.5	—	—	—
Breadth of nasals at anterior ends (distal)		175	5.0	10.8	—	—	—
〃 〃 〃 〃 〃 〃 (proximal)		137	3.9	8.5	—	—	—
〃 〃 〃 〃 posterior ends		49	1.4	3.0	—	—	—
〃 〃 frontal plane post. to premax.		217	6.2	13.4	—	—	—
〃 〃 orbit (frontal wing)		234	6.7	14.5	233	7.6	17.5
Breadth of occiput between squamosal sutures		1,118	32.1	69.2	876	28.6	65.6
〃 across occipital condyles		266	7.6	16.5	251	8.2	18.8
Height of occipital condyle		174	5.0	10.8	167	5.5	12.5
Breadth of foramen magnum		53	1.5	3.3	84	2.7	6.3
Height of foramen magnum		45	1.3	2.8	97	3.2	7.3
Length of mandible (straight)	R	3,305	95.0	204.6	2,891	94.4	216.6
	L	3,315	95.3	205.3	2,898	94.6	217.1
〃 〃 〃 (on curve)	R	3,540	101.7	219.2	2,970	97.0	222.5
	L	3,645	104.7	225.7	3,009	98.3	225.4
Height of mandible at coronoid	R	397	11.4	24.6	342	11.2	25.6
	L	392	11.3	24.3	339	11.1	25.4
〃 〃 〃 〃 proc. articularis	R	302	8.7	18.7	268	8.8	20.1
	L	301	8.6	18.6	276	9.0	20.7
〃 〃 〃 〃 middle	R	214	6.1	13.3	225	7.3	16.9
	L	217	6.2	13.4	223	7.3	16.7

* Nasals missed.

the latter photograph is taken from a slightly obliquely posterior position and does not show correct proportion on this point.

The nasals of the Ayukawa specimen of *edeni* are more tapering backwards than in the Pulu Sugi specimen of *edeni* and the specimens of *brydei* in the British and South African Museums, and their posterior ends are separated by a forwardly directed process of the frontals. These characters are, however, less important for the taxonomic purpose. The most remarkable difference between *edeni* (and *brydei*) and *borealis* in the form of nasals is observed in the front margin. In all the specimens of *edeni* and *brydei* ever reported the front margin of nasals is bent forward on the outer side, whereas in *borealis* straight. The Ayukawa specimen of *edeni* agrees quite well in this character as shown in Plate I, Fig. 1.

The another important point which separates *edeni-brydei* from *borealis* is the relation between the front margin of nasals and the anterior border of the posterior maxillary concavity. In *edeni* and *brydei* the front margin of the nasals is situated far behind this concavity, but in *borealis* they reach almost to this level. The Ayukawa specimen of *edeni* agrees in this respect too, the front margin of nasals (median) being situated about 15 cm behind this concavity.

Lönnberg stresses the point that the flat area formed by the nasals and the hind part of the maxillaries is longer than broad in *brydei*, whereas in the sei whale it is square or broader than long. Junge (l. c., p. 9), however, describes that this character is variable therefore to be of no use. In our specimen of *edeni* this area is broader than long, as in the case of Pulu Sugi specimen, and does not agree with the Lönnberg's description.

The length of the supraoccipital bone measured from the foramen magnum to the frontal suture is 24.0% of the length of skull in the Ayukawa specimen of *edeni*, whereas 25.1% in *borealis* taken in the same locality. Junge (l. c., p. 9) found the range for *brydei* to be 23.9–24.9%, and for *edeni* 22.2–23.8%. He concludes that the supraoccipital is therefore longer in *brydei* than in *edeni*, though he deems this character is of no essential value. Our specimen of *edeni* falls within the range for *brydei* and does not fall in that for *edeni*.

The breadth of occiput between squamosal sutures is 32.1% of the skull length in the Ayukawa specimen of *edeni*. Junge (l. c., p. 9) also describes that the measured skulls of *brydei* (32.4–35%) and *edeni* (28.3–31.3%) are different in this respect, but our specimen of *edeni* is more closely related to the above figures for *brydei* than those for *edeni*.

The deep and narrow sulcus between the articular and squamosal parts

of the temporal is present in the specimen of *borealis*, but nearly absent in the specimen of *edeni*, both from Ayukawa. There are also each one specimen of *edeni* and *borealis* in the National Science Museum in Tokyo. In these specimens too the sulcus is present in *borealis* and absent in *edeni*. This sulcus is also present in *physalus*, but absent in any specimens of *acuto-rostrata* from the coast of Japan. According to Junge (l. c., p. 10) this sulcus, but feebly developed, is also present in the two skulls of *edeni* in the Calcutta Museum and absent in his Pulu Sugi specimen. He concludes that though variable in development this sulcus is narrower and deeper in most specimens of *borealis* than it is in *brydei* or *edeni*, and this is also supported by specimens of both species from the coast of Japan.

In the ventral region of the skull there are also some characters which are said as separating *brydei* and *edeni* from *borealis*. One character is that the palatines do not reach so far backwards in *brydei* and *edeni* as in *borealis*. Junge (l. c., p. 10) reports that the proportional length between the posterior ends of the palatines in the mesial line and the occipital condyles against skull length are 8.5–12.9% in *borealis* (5 specimens) and 11.8–14.8% in *brydei* and *edeni* (5 specimens). In our specimen of *edeni* the length from the tip of premaxillaries to posterior end of palatines (mesial) is 83.6% of the skull length (Table 2), and agrees in this respect. In the Andrews' specimen of *borealis* from the coast of Japan (l. c., Plate XLI, Fig. 2) this part of the skull is rather short, being about 11% of the skull length measured from the photograph. But in the specimen of *borealis* from Ayukawa this length is about 16% of the skull length. In the both specimens of *borealis* the vertebral epiphyses are all free, hence physically immature. This character, therefore, may subjects to individual variation.

Another character which is said also to separate *brydei* and *edeni* from *borealis* is the form of the basicranial part exposed behind the palatines. This part of the skull is about squarish in outline in *borealis*, whereas in *brydei* and *edeni* much longer than broad in general though to a varying degree. In our specimen of *edeni* this part of the skull is much longer than broad when compared with the skull of the Andrews' specimen, but also in the specimen of *borealis* from Ayukawa this part is much longer than broad. And I can not distinguish the two species from Ayukawa in the above noted two characters.

It is also reported that the skull of *brydei* and *edeni* has more longer and slender hammular processes of pterygoids. In our specimen of *edeni* their lengths are 101 and 103 mm respectively and more slender compared with that of *borealis*.

The tympanic bullae of our specimen measure : right 117 mm in length

and greatest breadth 90 mm, left 118 mm in length and 89 mm breadth. They are larger than those of Pulu Sugi specimen and similar in general to those of Lönnberg's specimen of *brydei*.

Lacrymals (Fig. 1) are generally flat and their proximal ends are very thin, but distal ends thickend. The lengths of right and left are 273 and 270 mm respectively, and their breadths are 87 and 94 mm at distal ends and greatest breadth at middle 114 and 112 mm respectively. They articulate between frontals and maxillaries.

Fig. 1. Lacrymals (left) and malars (right) of *edeni* from the coast of Japan.

Malars (Fig. 1) are short and curved towards posterior ends, and broadened at their anterior ends, where they articulate with lacrymals and maxillaries. Length of the right and left bones are 285 and 282 mm, and breadth at anterior ends are 211 and 205 mm respectively. Breadth at middle is 42 mm in both bones.

Mandible (Plate III, Figs. 2 & 3). Measurements of mandibles of our specimen of *edeni* are also given in Table 2, together with those of *borealis* processed at the same landstation. As shown in this table practically there is no difference in the proportional length of the mandibles against skull length between the two species when measured in straight line, but when measured on curve *edeni* has more longer mandibles than *borealis*. This means that the mandibles are more curved inwardly in *edeni* and this fact corresponds to the more curved outer edges of maxillaries in this species than *borealis*. In the height of the mandibles the measurements of two specimens agree well each other, except the height of mandible at its middle, in which *edeni* shows less value. But I had an impression that the mandible of *edeni* is much thicker and heavier than that of *borealis*. In other words the cross section of mandible at its middle is more rounded in outline in *edeni* and flat in *borealis*. In the specimens of *borealis* and *edeni* kept in the National Science Museum in Tokyo the thickness of mandible at their middle are 124 and 137 mm

respectively, their length being 3390 and 2925 mm measured in straight. And these thickness are 53.7% in *borealis* and 64.3% in *edeni*, when expressed as percentages of the height at the same points. We can safely conclude, therefore, that *edeni* has more thicker mandibles than *borealis*.

There are some characters in mandible which are said also to separate *brydei* and *edeni* from *borealis*. One of these is the groove between the angular and articular parts of the mandible. This groove is deeper in *borealis*, but much less developed in *brydei* and *edeni*. Our specimens of *borealis* and *edeni* agree quite well in this respect.

Another difference between *borealis* on the one hand and *brydei* and *edeni* on the other is the relation between angular and articular portions. According to Junge (l. c., pp. 11–2), in *brydei* and *edeni* the angular portion is at equal level or projects behind the articular part, whereas in *borealis* the former ends before the hind edge of the latter. And moreover in *borealis* the angular portion is found much more on the medial side of the mandible than *edeni*, where they are much in a vertical line above each other. Our specimens of *edeni* and *borealis* from Ayukawa agree in these characters too.

Vertebrae (Plates IV & V). The vertebral formula of our specimen of *edeni* is C 7, D 13, L 13, Ca 21, which makes the total number of vertebrae 54. The measurements of the vertebrae are shown in Table 3. The total number of vertebrae of *brydei* and *edeni* is reported as 52 or 53. Lönnberg (1931) reports that in his specimen of *brydei* there are 52 vertebrae. Anderson (1878) gives the vertebral formula of his type specimen of *edeni* as C 7, D 10, L 14, Ca 21=52. But in this case, actually only 47 vertebrae have been preserved and he thought that there are 2 more probably after the 41st vertebra, and, at the termination of the caudal portion, 3 to be wanting. Junge (l. c., pp. 17–8) describes that in the London specimen of *edeni* there are 7 cervical, 12 dorsal, 12 lumbar and 16 caudal vertebrae present, but four or five of the hindmost vertebrae are lost, which makes the total 52 or 53 vertebrae. And in the London specimen of *brydei* 7 cervical, 12 dorsal, 14 lumbar and 19 caudals (perhaps the last one lost) are found, which makes a total of 52, perhaps 53 vertebrae. Further he reports that in his Pulu Sugi specimen there present 7 cervical, 13 dorsal, 13 lumbar and 18 caudal, but certainly one, perhaps two of the last caudals have been lost, and this makes a total of 52 or perhaps 53.

As stated above there remains still some question as to the total number of vertebrae in *edeni* and also in *brydei*. Omura & Fujino (1954) report that *edeni* processed at Ayukawa in 1953 had 54–55 vertebrae, out of a total number 13 investigated 5 being 54 and 8 samples 55. The present specimen of *edeni* from Ayukawa agrees in this res-

TABLE 3. MEASUREMENTS OF VERTEBRAE OF *edeni* FROM THE COAST OF JAPAN (in mm)

Serial No.	Vertebral No.	Greatest breadth	Greatest height	Centrum			Neural canal	
				Breadth in front	Height in front	Length	Breadth	Height
1	C 1	471	298	2) 260	2) 186	84	81	133
2	2	750	311	2) 270	2) 165	48	118	92
3	3	645	311	220	142	50	118	81
4	4	658	304	213	159	62	121	73
5	5	623	311	210	165	59	129	70
6	6	565	333	215	175	63	136	69
7	7	586	366	218	172	75	134	71
8	D 1	583	362	219	170	86	138	72
9	2	601	304	218	166	106	128	73
10	3	566	423	228	167	123	118	75
11	4	632	466	233	168	141	111	76
12	5	695	490	230	165	151	102	83
13	6	752	524	226	165	157	97	74
14	7	807	551	222	165	174	82	77
15	8	838	576	219	164	185	74	73
16	9	853	601	221	171	187	75	68
17	10	889	620	226	174	197	68	60
18	11	930	627	225	176	201	68	67
19	12	1) 970	630	228	176	202	68	64
20	13	950	645	233	174	215	60	59
21	L 1	922	662	233	182	220	59	57
22	2	920	658	235	184	228	55	73
23	3	913	647	237	186	233	57	73
24	4	915	655	243	188	240	56	74
25	5	889	672	240	197	242	58	64
26	6	872	676	241	198	248	57	52
27	7	844	681	243	201	252	57	55
28	8	821	686	248	197	257	51	58
29	9	802	688	251	199	260	55	45
30	10	761	689	253	206	268	52	50
31	11	742	689	258	212	273	45	55
32	12	730	682	266	215	278	42	53
33	13	651	680	273	221	273	34	53
34	Ca 1	630	660	277	233	270	33	49
35	2	582	600	273	238	271	30	40
36	3	571	530	277	237	272	27	42
37	4	505	457	277	235	265	27	37
38	5	432	409	277	232	260	24	28
39	6	362	366	271	231	254	23	22
40	7	335	344	273	228	246	17	13
41	8	307	317	262	225	237	15	7
42	9	281	288	254	221	226	10	7
43	10	266	260	243	219	213	13	6
44	11	237	238	222	209	182	12	7
45	12	199	220	190	198	124	8	6
46	13	180	160	165	152	85	—	—
47	14	—	139	151	129	70	—	—
48	15	—	130	129	119	76	—	—
49	16	—	120	108	107	75	—	—
50	17	—	102	91	93	67	—	—
51	18	—	78	78	71	55	—	—
52	19	—	—	63	57	46	—	—
53	20	—	—	51	41	42	—	—
54	21	—	—	38	27	38	—	—

1) Left transverse process broken. Twice right half.
2) Articulating face.

pect, having 54 vertebrae. I had an opportunity to observe the Pulu Sugi specimen kept in the Rijksmuseum van Natuurlijke Historie, Leiden, by the courtesy of Dr. G.C.A. Junge, and measured some of the caudal vertebrae, which are shown in Table 4 compared with those of the Ayukawa specimen of *edeni*.

TABLE 4. SELECTED MEASUREMENTS OF VERTEBRAE OF *edeni* (in mm)

Vertebral No.	Pulu Sugi specimen			Ayukawa specimen		
	Greatest breadth	Greatest height	Length	Greatest breadth	Greatest height	Length
45	201	199	131	199	220	124
46	175	166	108	180	160	85
47	149	143	94	151	139	70
48	131	128	90	129	130	76
49	116	116	86	108	120	75
50	100	98	77	91	102	67
51	78	87	69	78	78	55
52	—	—	—	63	57	46
53	—	—	—	51	41	42
54	—	—	—	38	27	38

As seen from this Table each corresponding vertebra agrees in general in dimension, except in length of vertebra where Pulu Sugi specimen has somewhat greater value. In all vertebrae of the Pulu Sugi specimen the epiphyses are coalesced completely with the rest of the vertebral body. In the Ayukawa specimen, on the other hand, such fusions are only observed in the anterior region up to the anterior epiphysis of the 4th, and in the posterior region in the last lumbar (33rd vertebra) and in all of the caudals. We can conclude, therefore, that the Pulu Sugi specimen is older in age than the Ayukawa specimen. But it seems that the former is somewhat shorter in body length than the latter. The body length and sex of the Pulu Sugi specimen was unknown, and the length of the skeleton is reported as slightly over 12 m. The Ayukawa specimen was a female of 45 feet in length. The skull length of the two specimens are 3160 and 3480 mm, the Pulu Sugi specimen being shorter than the other. It is possible, therefore, that the Pulu Sugi specimen was shorter in body length than the Ayukawa specimen, regardless of its higher age. But, still we can not deny the possibility that in the Pulu Sugi specimen there were present 3 more caudal vertebrae, instead of 2, though in some of its caudal vertebrae their lengths are a bit larger than the corresponding vertebrae of the Ayukawa specimen. And if we assume that this is a matter of fact, then the vertebral formulae of the two specimens are exactly the same, i.e. C 7, D 13, L 13, Ca 21=54.

The cervical vertebrae of our specimen of *edeni* are all free and no fusion among these bones were observed. The atlas has short and much twisted transverse processes. In the specimens of *brydei* and *edeni* ever reported these processes are much pointed than in *borealis*, but in our specimen no such character is observed and I can not distinguish it from *borealis*. It is possible, however, that such form is much changeable according to age. Our specimen of *edeni* was adolescent one, because most of the epiphyses are not fused to their centra as stated before.

The posterior process on the lower edge of the body and pointing to the axis is short and obtuse. The canal for the first spinal nerve is open. The articular facets for the occipital condyles are separated in major parts, but confluent in the lower parts, being placed obliquely each other.

The axis of our specimen of *edeni* resembles in general to that of Pulu Sugi specimen. The distal ends of the wing-like processes are more squarer than those of *borealis*, which are generally rounded. The holes on these wing-like processes are rather small in our specimen, their long diameters being 80 and 83 mm.

In the 3rd cervical vertebra the ring formed by dia- and parapophyses is closed on both sides. And at each distal end of both rings, a bit apart from the ring, there present a small bone (Plate V, Fig. 1). The one on the left side is nearly rounded in outline, their diameters being 60 and 77 mm. This bone was connected with the ring by cartilage. Another one on the right was not ossified yet, but cartilage of 114 mm long and 37 mm width. These facts show that the rings were still in the process of growth.

In the 4th, 5th and 6th vertebrae also such rings present. They are all closed, but the parapophyses on the left side of the 4th and on the both sides of the 6th have no communication with the vertebral body. The diapophyses are well developed in the 7th, but the parapophyses of the vertebra are found as small tubercles on the vertebral body. Since there are great variability in the formation of ring and form of the dia- and parapophyses in specimens of *brydei* and *edeni* hitherto reported, such characters are of doubtful value for the diagnostic purpose.

The most remarkable difference which separate *brydei* and *edeni* from *borealis* in the form of vertebrae is the strong backward inclination of the spinous processes in the former. This inclination begins in the 7th dorsal vertebra in the Pulu Sugi specimen and increases till it reaches its maximum in the 7th lumbar (Junge, l. c., p. 14). And the similar is reported for the Anderson's specimen of *edeni* and also in specimens

of *brydei*. They all agree in general in this character. Lönnberg and Junge measured the distance at which the vertical plane along the posterior surface of the vertical body reaches the upper margin of the spinous process reckoned from the anterior and posterior upper angle of the process. These measurements are more or less approximate for it is difficult to take exact measurements. But still useful in general comparison.

In our specimen of *edeni* too, the backward direction of the spinous process is notable (Plate IV). It begins in the 7th dorsal vertebra (14th vertebra) and increases till it reaches its maximum in the 5th lumbar (25th vertebra). In all vertebrae from the 2nd lumbar (22nd vertebra) to the 10th lumbar (30th vertebra) the vertical plane along the posterior surface of the vertebral body falls before the anterior angle of the spinous process. I also took similar measurements as taken by Lönnberg and Junge, which are shown in Table 5. These figures show close agreement each other.

TABLE 5. BACKWARD INCLINATION OF SPINOUS PROCESSES IN *edeni* AND *brydei* (in cm)

Vertebral number	Distance of posterior angle of processus spinous		
	Pulu Sugi *edeni*	Lönnberg *brydei*	Ayukawa *edeni*
13	4.5	5	—
14	8	7	—
15	9	7	—
16	11	7.5	—
17	12	10	—
18	13	13.5	12
19	14	13	13
20	18	13	17
21	20	—	16.5
22	20	—	21
23	20.5	—	23.5
24	23	—	24.5
25	26	—	25.5
26	—	—	25
27	—	—	25
28	—	—	23
29	—	—	20.5
30	—	—	21.5
31	—	—	18.5
32	—	—	15
33	—	—	10

Our specimen of *edeni* has 13 dorsals and 13 lumbars as stated above. The spinous process in the 1st dorsal vertebra is rather low and blunt pointed. From the 2nd on they show a square top and increase in

height. The first 12 dorsal vertebrae have more or less well marked facets at the distal ends of the transverse processes for the articulation of the ribs. The 13th dorsal vertebra has a well marked facet at the distal end of the right transverse process, but on the left no such facet present, though the distal end of the process somewhat thickened (Fig. 2).

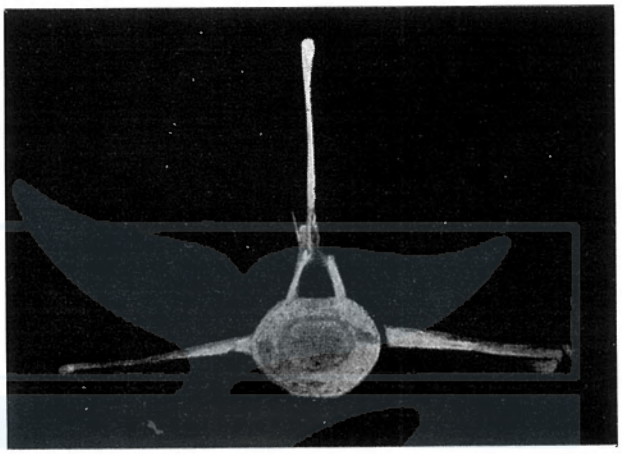

Fig. 2. 13th dorsal vertebra of the Ayukawa specimen of *edeni*. Posterior view.

As seen in Table 7 the 13th right rib is similar in size to the preceding two ribs, but unfortunately all of the left ribs, except the foremost 3, were missed. I can not able, therefore, to discuss this point in relation to ribs.

The transverse process in our specimen of *edeni* are directed forward in the first 6 dorsal vertebrae, those of 7th, 8th and 9th outward, from 10th dorsal on backward till 1st of lumbar, and those of remaining again outward.

The 1st caudal vertebra is detected by the presence of bifurcated median carina on the inferior side of the vertebral body. In the caudal vertebrae the spinous process diminishes its height rapidly and it disappears completely in the 13th caudal (46th vertebra), and rudimental in the preceding two. The neural canal in our specimen is closed to the 13th caudal. Also the transverse process decreases its length rapidly and diminishes on the 12th caudal (45th vertebra). The first vertebra with transverse processes perforated by vertical foramen is the 4th caudal (37th vertebra) in our specimen of *edeni*. In this vertebra the perforation is visible on both transverse processes.

In the above mentioned characters in the caudal vertebrae our specimen of *edeni* is somewhat different from the Pulu Sugi specimen and other specimens of *edeni* and *brydei*. But, it is possible that these are

matters of individual variations. Junge (l. c., p. 18) reports that in his Pulu Sugi specimen spinous process has disappeared by the 9th, and neural canal is closed to the 11th. But, up to 12th caudal there remain still some tubercles on the superior sides of vertebrae, and nothing on the 13th (Plate VIII, Fig. 3 of his report). Our specimen of *edeni* agrees quite well in this respect (Plate IV, Fig. 3).

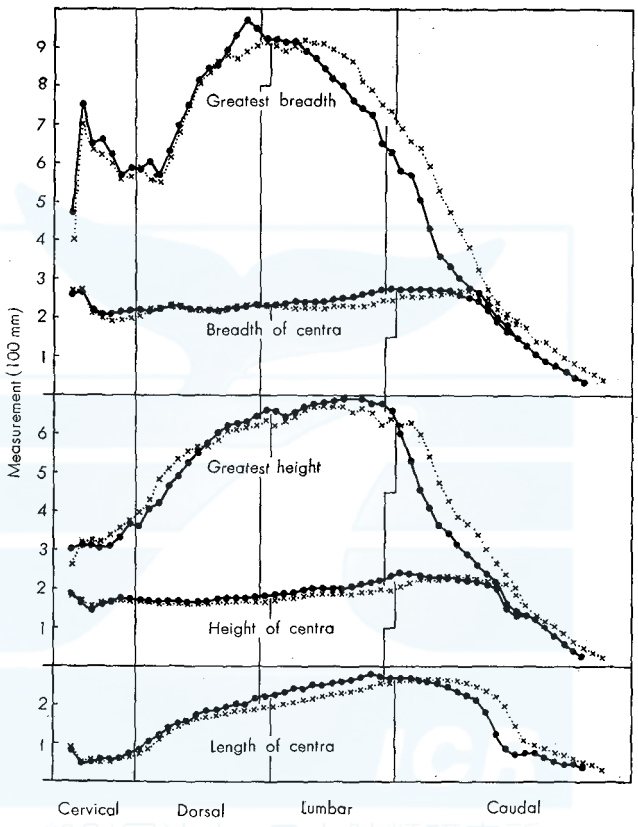

Fig. 3. Dimensions of vertebrae in *edeni* and *borealis*.

In Fig. 3 the measurements of vertebrae of our specimen of *edeni* are compaired with those of *borealis*. The vertebral formula of this *borealis* is C 7, D 14, L 13, Ca 22=56. The measurements of skull of this specimen are included in Table 2. As shown in Fig. 3 the curves for *edeni* and *borealis* are similar in general, if we consider the different number of vertebrae of both specimens.

Chevron bones (Fig. 4). Our specimen of *edeni* has 12 chevron bones. The 1st attached to the inferior and posterior part of the 34th vertebra. The right and left laminae of the first and the last are not united each other, and in all of the rest united. Measurements of each bone are

shown in Table 6. The 6th is the largest, and the last smallest. In the Pulu Sugi specimen 11 chevron bones have been secured, but Junge deems probably the first two have been lost. In the Lönnberg's specimen of *brydei* 9 chevron bones present, but 2 last are lacking. Our specimen of *edeni* was confirmed at fresh that it had 12 chevron bones.

Fig. 4. Chevron bones of *edeni* from the coast of Japan.

TABLE 6. MEASUREMENTS OF CHEVRON BONES OF *edeni* FROM THE COAST OF JAPAN (in mm)

No.	Breadth	Height	Remark
1	{ 78 { 69	103 109	not united
2	83	197	
3	116	218	
4	170	208	
5	155	239	
6	179	250	
7	175	239	
8	157	171	
9	129	157	
10	130	111	
11	115	73	
12	{ 72 { 74	50 54	not united

Pelvic bone (Fig. 5). Both pelvic bones have been secured. They are nearly straight entally, while ectally the region of junction of ilium and ischium is marked by the small projection of the pubis, and the ilium constricted around the middle. The lengths of right and left bones are 259 and 257 mm and their breadth at pubis are 43 and 41 mm respectively.

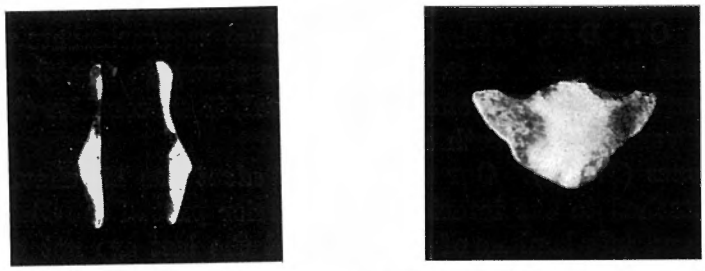

Fig. 5. Pelvic bones (left) and sternum (right) of *edeni* from the coast of Japan.

Sternum (Fig. 5). In our specimen of *edeni* the sternum is cross shaped as in other specimens of *edeni* and *brydei*, but the anterior process is much reduced and the posterior process less pronounced. The length is 180 mm, the breadth across the transverse arms 288 mm. The proportional length is 62.5% of the breadth, which is very near to that of the Pulu Sugi specimen (61.2%).

Ribs (Plate VI). Our specimen of *edeni* has 13 pairs of ribs. All of the right ribs have been saved, but in the left only the first 3 secured. The 1st rib is deeply bifurcated at the head, by a narrow cleft of about 10 cm deep, and broadly expanded at the distal end. The head for the last cervical is longer and broader than that for the 1st thoracic vertebra.

TABLE 7. MEASUREMENTS OF RIBS OF *edeni* FROM THE COAST OF JAPAN (in mm)

Rib No.	Right		Left[1]	
	Length, straight	Breadth, distal end	Length, straight	Breadth, distal end
1	910 (875)[2]	215	908 (875)[2]	190
2	1,233	73	1,203	72
3	1,390	77	1,370	76
4	1,495	79		
5	1,547	73	—	—
6	1,572	broken	—	—
7	1,573	58	—	—
8	1,516	51	—	—
9	1,468	47	—	—
10	1,308	40	—	—
11	1,256	39	—	—
12	1,243	32	—	—
13	1,258	37	—	—

1) All ribs other than nos. 1, 2 and 3 were missed.
2) Figures in brackets show the length from the second head.

Anderson (1878) reports that in his type specimen of *edeni* only a fragment of the first rib of the left side and the entire sixth rib of the same side were saved. As to the former he describes that it is single-headed, and the head and tubercle are well-developed. Other specimens of *edeni* and *brydei* ever reported all have bifurcated first rib, as in the case of *borealis*.

In our specimen of *edeni* there is a rudiment of a capitulum and collum in the 2nd rib of both sides, but absent in the 3rd and 4th of the right side. In the left side, however, collum is also present in the 3rd (Plate VI, Fig. 2), but unfortunately all ribs from the 4th on have not been saved. In the Pulu Sugi specimen the rudiment of capitulum and collum is present in the 2nd, 3rd and 4th ribs.

The measurements of the ribs in our specimen are shown in Table 7. As stated before, practically no difference in size is noted in the last 3 ribs on the right side.

Hyoid bone (Fig. 6). In our specimen of *edeni* basihyals and thyrohyals are united completely into a mass. It is more slender than that of

Fig. 6. Stylohyals (upper) and combined bone of basihyal and thyrohyals of *edeni* from the coast of Japan.

borealis used for comparison. Its transverse diameter is 745 mm, and the length mesially between the forward projecting processes 153 mm. This length is 20.7% of the overall breadth, whereas in *borealis* the same length is 25.5% of the breadth. The median notch is narrow and deep, its depth being 94 mm. In our specimen one of the forward projecting processes is broken. Stylohyals are also more slender and less curved than those of *borealis*. This point may be of some importance, because in the Andrews' specimen of *borealis* stylohyals are also more curved. In our specimen of *edeni* one of the stylohyals is 444 mm in length and 133 mm breadth, and the another 444 and 143 mm respectively. The breadths are 30.0% and 32.4% of their lengths, and the corresponding figures in *borealis* are 34.5% and 36.4%.

In these respects our specimen of *edeni* agrees well with the Pulu Sugi specimen.

Scapula (Fig. 7). In our specimen of *edeni* only the left scapula has been saved. It has a form generally found in *borealis* or other species of balaenopterid whales. The greatest length measured from angle to angle is 910 mm and its height is 537 mm. The height is 59.0% of the length, which is similar to those of other specimens of *edeni* and *brydei* reported. But, it is also similar to the measurements in *borealis* used for comparison. In this specimen of *borealis* the corresponding figures for the right and left scapulae are 58.8% and 58.1% respectively.

In our specimen of *edeni* the length of the acromion is 248 mm and not broadening toward the end. The coracoid is 154 mm in length, which is much longer than that of *borealis* used for comparison. It is longer than that of Pulu Sugi specimen by about 70%, though in other measurements any particular differences are noted between the two specimens. The glenoid fossa of our specimen is 195 mm in length and 139 mm width.

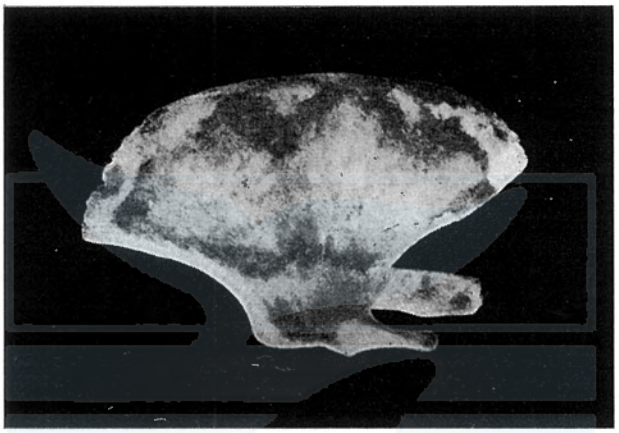

Fig. 7. Scapula of *edeni* from the coast of Japan.

Humerus, Radius, and Ulna (Plate V, Fig. 3). In our specimen of *edeni* these bones were saved only from right side. The length of the humerus is 371 mm and the breadth at its middle 154 mm. Its proximal and distal epiphyses are united completely to the body. In the radius and ulna their proximal epiphyses are united to their bodies but the distal epiphyses are not united. The radius measures 607 mm in length, excluding the distal epiphysis, and breadth at its middle 105 mm. The corresponding figures in the ulna are 568 (between articulating surfaces) and 59 mm, also excluding the distal epiphysis, and the length from orecranon is 640 mm. In our specimen the length of the humerus is 61.1% of the length of the radius. Junge (c. l., p. 21) found that this proportional length is 51.9–54.2% in *edeni* and 56.9–63.3% in *brydei*. He does not think, however, that this differences is an essential one, for this proportional length of humerus can vary to a large extent. His opinion is well supported by our specimen of *edeni*.

Carpals and Phalanges (Plate V, Fig. 3). Carpals and phalanges were also secured only from the right side. Carpals were still embedded in cartilages when I examined, and the ossifications of the radiale, intermedium, ulnare, as well as 2 carpalia were observed. The phalanges were incompletely saved, and surely some of the digits were missed. I can

not give, therefore, the formula for the phalanges. In Table 8 the measurements of the saved phalanges are shown for reference.

TABLE 8. LENGTHS OF PHALANGES OF *edeni* FROM THE COAST OF JAPAN (RIGHT SIDE) (in mm)

		II	III	IV	V
1	Phalanx	115	125	115	90
2	〃	117	119	106	70
3	〃	93	93	92	70
4	〃	66	67	70	—
5	〃	44	50	67	—
6	〃	45	—	—	—

Discussion. Junge (l. c., pp. 22–3) points out many characters in the skeleton, which separate both *Balaenoptera edeni* and *B. brydei* from *B. borealis* as follows:

1. The dorsal surface of the rostrum is mostly more straight and flat in *edeni-brydei.*
2. The ventral surface of the maxillaries is less concave in *edeni-brydei.*
3. The range of the rostrum length is larger in *edeni-brydei.*
4. The rostrum at its middle is broader in *edeni-brydei.*
5. The nasal processes of the maxillaries are narrowed in *edeni-brydei.*
6. The front margin of the nasals is bent forward on the outer side in *edeni-brydei,* straight in *borealis.*
7. The front margin of the nasals falls strinkingly behind the anterior border of the posterior maxillary concavity in *edeni-brydei,* at about the same level in *borealis.*
8. The sulcus between articular and squamosal parts of the squamosal is not so deep and narrow in *edeni-brydei.*
9. The palatines do not extend so far back in *edeni-brydei.*
10. The basicranial part of the skull exposes behind the palatines is much longer than broad in *edeni-brydei.*
11. The posterior horns of the pterygoids are longer and more slender in *edeni-brydei.*
12. The groove on the inner side of the mandible between articular and angular parts is shallower in *edeni-brydei.*
13. The angular portion of the mandible ends at level of, or behind, the articular part in *edeni-brydei,* in front of it in *borealis.*
14. The angular and articular parts are more vertical above each other in *edeni-brydei.*
15. The transverse processes of the atlas are smaller and more pointed in *edeni-brydei,* the process pointing to the axis is shorter and more obtuse.

16. The distal ends of the wing-like processes of the axis are squarer in *edeni-brydei*.

17. The spinous processes of the dorsal and first lumbar vertebrae show a strong backward inclination in *edeni-brydei*.

18. The total number of the vertebrae is 52–53 in *edeni-brydei*, against 56–57 in *borealis*.

In these characters he deems especially nos. 1, 2, 5, 6, 7, 13, 17 and 18 to be important. As shown above our specimen of *edeni* agrees strikingly in these important characters, except no. 18. In characters other than listed above our specimen of *edeni* agrees in nos. 4, 8, 11, 12, 14, and 16. Of 18 characters, therefore, our specimen agrees in 13, and these may need no further explanation.

In our specimen of *edeni* the rostrum length (no. 3) is larger as in *edeni-brydei* when this length is measured from the tip of the premaxillaries to the tip of the nasals, but it is not proved if measured from the same to the base of the rostrum, i.e. middle of the curved border of maxillaries. These facts mean that the nasals are situated more posteriorly in *edeni* than *borealis*. From a study on the external characters by Omura, Nishimoto and Fujino (1952) it is shown that the lengths from tip of snout to blow-hole and from the same to centre of eye are greater in *edeni* than *borealis*, though there is overlapping. But, in the length from tip of snout to angle of gape the difference between two species is not conspicuous. As shown above our specimen of *edeni* agrees with the the description of Junge also in no. 3, if we understand the meaning of rostrum length as that measured from nasals.

As regards nos. 9 and 10 our specimen of *edeni* agrees in these respects too, but another specimen of *borealis* from the coast of Japan also shows these characters, and I can not distinguish the two species from these points. These characters, however, may subject to age variation and it is hoped that adult specimens of the both species be compared in future.

Also in no. 15 our specimen of *edeni* shows a difference from what are described. The transverse process of the atlas are rather small and the process pointing to the axis is shorter and more obtuse in our specimen too, but the form of transverse processes are not pointed. There is a possibility, however, that this character is also subject to the age variation. Further the form of the transverse processes of the cervical vertebrae is deemed as of doubtful value as a diagnostic character.

The number of vertebrae (no. 18) is very important. All of our specimens of *edeni* ever recorded have 54–55 vertebrae in all, which are two vertebrae more than those recorded from other authors, but still less than that of *borealis*, which is 56–57. As already shown, however,

there is a question as to the counting of vertebrae by other authors, because they all include some guesswork. Further there is a possibility that the Pulu Sugi specimen of *edeni* has actually had 54 vertebrae, judged from the measurements of some of them from the caudal region. Careful counting on complete skeleton in future is needed. In the total number of the vertebrae of *borealis* from the coast of Japan we see no difference from those from other regions.

In conclusion above our specimen of *edeni* differs not in important characters which separate *edeni-brydei* from *borealis*. Further I noted some other differences between *edeni* and *borealis* from the coast of of Japan as follows:

1. The mandible is more thicker and more rounded in cross section in *edeni* and flat in *borealis*.
2. Stylohyals are less curved in *edeni* and more curved in *borealis*.

As to the differences between *edeni* and *brydei* Junge (l. c., p. 23) found the following characters in the skeleton, though he does not stress their importance.

1. The rostrum basally is broader in *brydei*, more slender in *edeni* than in *borealis*.
2. The proportional length of the supraoccipital is greater in *brydei*.
3. The proportional breadth of the occiput between the squamosal sutures is greater in *brydei*.
4. The proportional breadth of the frontal wing above the orbits is less in *brydei*.
5. The proportional length of the humerus is greater in *brydei*.

Our specimen of *edeni* resembles more to *brydei* in nos. 2, 3, and 5, and no difference is noted in the breadth of rostrum basally between our specimens of *edeni* and *borealis*. The breadth of the frontal wing above the orbits is very difficult to take the exact measurement. It may differ greatly according to the method of measurement. In conclusion our specimen of *edeni* supports the Junge's opinion that we can consider *edeni* and *brydei* conspecific, which makes the name *Balaenoptera brydei* Olsen a synonym of *Balaenoptera edeni* Anderson.

The Japanese common name for *edeni* has not being authentically given yet, but its dialectal name by whalers is 'Nitari', meaning of which is simply 'resemble' or 'like' and it originated from 'finwhale-like-seiwhale'. I should like to propose herewith the name 'Nitari-kujira' as the Japanese common name of *edeni*, in recognition of unknown whaler who firstly discovered the distinction of this species from the coast of Japan prior to 1950 when I started this study.

EXTERNAL AND OTHER CHARACTERS REVIEWED

External characters of *edeni* from the coast of Japan were studied by Omura, Nishimoto & Fujino (1952) and Omura & Fujino (1954), which are summarized as follows:

1. From a study of the body proportions it is proved that the anterior part of the body is larger and the posterior part is shorter in *edeni* compared with *borealis*; viz. the head is longer and broader, the blowhole and eye situated more posteriorly, the ear more apart from the eye, and the flipper attached more posteriorly; and to compensate for the increase of the head and shoulders the tail region undergoes a proportional decrease in the lengths from notch of flukes to posterior emargination of the dorsal fin and from the same to the anus and umbilicus. Further the dorsal fin is shorter in length and lower in height, hence smaller than *borealis*. On the other hand tail flukes are more wider at their insertion. The most important difference is, however, lying in the ventral grooves. In *borealis* the system of ventral grooves ends before or at an half way of the body and always anterior to the umbilicus, whereas in *edeni* it always extends after the half way of the body and ends posterior to or at the umbilicus.

2. In *edeni* the baleen plates are shorter in length, coarse in texture, greyish black in color and with thick bristles. The proportional lengths of baleen plates are 120–220% of their breadth, while in *borealis* the corresponding figures are 190–330%. The number of baleen plates is somewhat fewer in *edeni*.

3. In *edeni* the palate between the rows of the right and left baleen plates is broader than *borealis*.

The average body length at which sexual maturity is attained is reported by Omura (1950 b) as 40 feet or still smaller by one foot in males and 41 feet in females. Nishiwaki, Hibiya & Kimura (1954) studied the matter more closely and got to a conclusion that the sexual maturity is reached at 40 feet in males and 41 feet in females, being nearly the same to what found by Omura. It is possible from their study, however, that this length is 39 feet in males and 40 feet in females, if the length is understood as an average length which divides the catch figures into two groups of immature and mature whales for the examination of the condition of the stock (see Figs. 7 and 10 of Nishiwaki et al 1954).

Since 1955 catches of *edeni* on the coast of Japan have been recorded as this species, separated from *borealis*. We have now, therefore, full records of the catch of *edeni* for four years, in addition to those from the waters around Bonin Islands. These catch figures are shown

TABLE 9. CATCH OF *edeni* FROM THE COAST OF JAPAN

Year	Bonin Islands[1]			Sanriku[2]							Oshima[2]				West coast of Kyushu[2]					Total
	May	Jun.	Total	May	Jun.	Jul.	Aug.	Sept.	Oct.	Total	May	Jun.	Jul.	Total	Jul.	Aug.	Sept.	Oct.	Total	
1950	202	41	243																	243
1951	204	76	280																	280
1952	235	176	411																	411
1953																				
1954																				
1955				5	45	7	8	1	0	66	12	10	1	23	0	2	0	0	2	91
1956				0	12	6	2	3	1	24	0	0	0	0	0	0	2	1	3	27
1957				1	9	10	17	2	0	39	0	0	0	0	1	3	0	0	4	43
1958				2	5	46	127	0	0	180	2	60	12	74	0	5	37	5	47	301
Total	641	293	934	8	71	69	154	6	1	309	14	70	13	97	1	10	39	6	56	462
Monthly %	68.6	31.4	100.0	2.6	23.0	22.3	49.8	2.0	0.3	100.0	14.4	72.2	13.4	100.0	1.8	17.9	69.6	10.7	100.0	
Female %	46.3	36.2	43.1	50.0	62.0	62.3	59.1	83.0	100.0	60.8	64.3	51.4	30.8	50.5	100.0	40.0	48.7	50.0	48.2	

1) not operating since 1953.

2) not specified until 1955.

in Table 9.

As shown in Table 9 comparatively few *edeni* were taken in 1955, 1956 and 1957, but in 1958 a good number was taken. In Fig. 8 are shown the size distributions of *edeni* and *borealis* taken in 1958 on the coast of Japan, separately for both sexes.

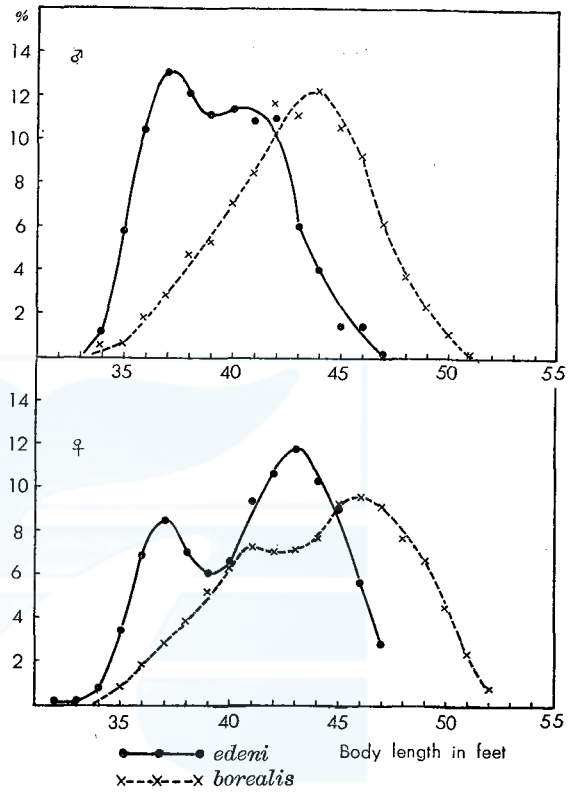

Fig. 8. Size distribution of *edeni* and *borealis* from the coast of Japan 1958. Smoothed.

It is clear from this figure that there is a marked difference in size distribution between *edeni* and *borealis*, the former being smaller than the latter by 4–5 feet. The biggest *edeni* is 47 feet in length for both sexes, whereas in *borealis* the longest is 51 feet in male and 52 feet in female. The curve for male *borealis* is nearly normal, but in male *edeni* and in females for the both species they draw bi-modal curves.

In these 3 curves we can consider that the first maxima represent the immature group and the second matured. In male *edeni* the first maximum is at 37 feet and the second at some length between 39 and 42 feet. In females the first maximum is at 37 feet and the second 43 feet in *edeni*, while in *borealis* at 41 feet and 46 feet respectively. The differences between the corresponding maxima of the two species are 4 feet and 3 feet.

Chittleborough (1959) reports that three Bryde's whales were taken off Shark Bay, Western Australia in October 1958. And he remarks that both mature individuals (out of three) were far smaller than mature specimens recorded from the Bonin Islands and the South African coast. The one is a female of 38 feet 6 inches in length and contained 11 corpora albicantia in its ovaries, and the another is a male of 36 feet 10 inches long and the weight of its testes are 2.7 and 2.6 Kg. It is true that these specimens are far smaller than our specimens from the coast of Bonin Islands.

As already stated it is probable that the Junge's specimen from Pulu Sugi is also smaller than our specimen from Ayukawa. The Pulu Sugi specimen was a full grown adult and our specimen was an adolescent one, but still the former has a shorter skull length than the other by 32 cm. It is probable, therefore, that the size of Bryde's whale differs according to locality where it was taken, from which it is suggested that there might occur some local races.

The difference in weight of various parts of body between *edeni* and *borealis* was reported briefly by Omura (1950 a) and more in detail by Fujino (1955). From those reports it is concluded that *edeni* is more heavier than *borealis* of similar size in total weight as well as in weights of blubber and bones, but weight of meat is lesser. In bones the weights of skull, jaw bones and back bones are all heavier than those of *borealis*.

The fact that the skull is heavier than that of *borealis* agrees to the larger head portion in *edeni*, found from a study of body proportions. We should consider however in this relation the probability that this is caused by the difference in age. In blue and fin whales the anterior part of the body up to the axilla becomes relatively larger and the posterior part correspondingly smaller with increasing total length, up to a point (Mackintosh & Wheeler, 1929). The specimens of *edeni* we used in these studies were all taken in the waters around Bonin Islands by pelagic whaling, in which 40 feet is the size limit for this species. As stated above the average body length of sexual maturity of *edeni* is around this size limit for both sexes. Accordingly most of them were sexually matured. On the other hand the specimen of *borealis* were taken from landstations on the northeast coast of Honshu (Japan proper), where whalers are allowed to take smaller whales by 5 feet. Further the average body length of sexual maturity of *borealis* is longer than *edeni* by about 4–5 feet. It is true, therefore, that the specimens of *edeni* we used were older in general than those of *borealis*. According to Matthews (1938), however, in sei whale from the southern hemisphere growth is much more evenly distributed throughout the body and that marked differential growth in favour of the anterior region does not occur to anything like the extent that it does in the larger whales. This was foreseen also in *borealis* from the coast of Japan as well as in matured *edeni* by Omura (1952). No sufficient material has been obtained since then, which enables us to examine in detail in this point, and still there remains some doubts which need future study, though in general we can consider that these differences may occur among different species.

DISTRIBUTION

As shown in Table 9 *edeni* has been taken in the waters around Bonin Islands, off Sanriku (northeast coast of Japan proper) and Oshima (on the south coast of Japan proper) and also in the west coast of Kyushu (East China sea). Omura & Fujino (1954) describe that herds of *borealis* come near to Bonin Islands in a period from December to middle of April, while those of *edeni* approach to the islands from the middle or end of April, and most frequently in May. In the waters off Sanriku also *edeni* is taken, but lesser in number than *borealis*. But in the waters off Oshima and in the west coast of Kyushu only *edeni* was recorded in the catch in the four years from 1955 and no *borealis* has been taken. We can consider, therefore, that *borealis* immigrates only to the east side of Japan, and *edeni* occurs not only in these waters but also on her south and west coasts.

Fig. 9 shows the monthly catch of *edeni* in the coast of Japan, based on the percentage figures shown in Table 9. In the Bonin Islands' waters about 70% of the total catch was taken in May and 30% in June. In April the catch is nil, but this is because of the restriction on whaling imposed which prohibited the taking of baleen whales in April. On the coast of Oshima over 70% was taken in June and in the waters off Sanriku about 50% of the catch was attained in August. In the west coast of Kyushu the highest catch was recorded in September. From above we may conclude that *edeni* is also migratory animal like other balaenopterid whales, though its range is restricted within tropical and sub-tropical waters. Omura & Nemoto (1955) report that the northern limit of distribution of *edeni* on the coast of Japan is nearly coincide with the isotherm of 20°C of surface water. Very roughly it can be expressed by a straight line of 40°N Latitude, though the whale may straggle beyond this line on some occasions. On the other hand the distribution of *borealis* extends up to south of Komandorskie Islands (55°N) and Aleutian Chain (Omura, 1955). Nemoto (1959) presents supposed migration routes of *edeni* on the coast of Japan.

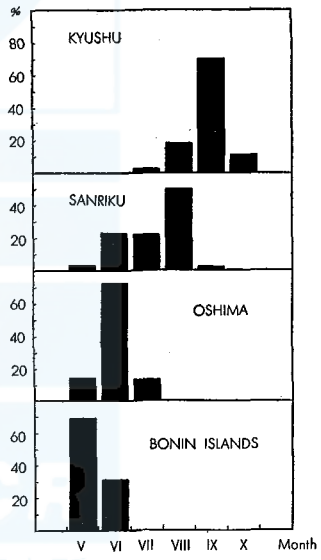

Fig. 9. Monthly catch of *edeni* in the coast of Japan, based on the material shown in Table 9. (Percentage figures)

As seen in Table 9 the sex ratio of the catch of *edeni* in the waters of Bonin Islands is quite different from that of Sanriku. In the former

region females consist about 43% of the total catch, while in the latter about 40% of the catch is male. This will suggest that segregation between both sexes takes place in some extent in the migration of *edeni*. In other regions no such segregation between sexes is observed.

As to the world distribution of *edeni* various authors report that this species occurs on the coasts of Durban and Saldanha Bay (Olsen, 1913), Angola, Congo, French Equatorial Africa (Ruud, 1952), Burma (Anderson, 1878), Singapore (Junge, 1950), Borneo (Harrisson and Jamuh, 1958), West coast of Australia (Chittleborough, 1959), Lower California (Kellogg, 1931) and it is said that it has also been recorded from the West Indies and Norway (Mackintosh, 1947; Fraser, 1937), but the identification at the last locality is very doubtful. Records of occurrences in these localities are shown in Fig. 10, in which the isotherms of 20°C in August (Northern hemisphere) and in February (Southern hemisphere) were drawn according to Sverdrup, Johnson and Fleming (1942).

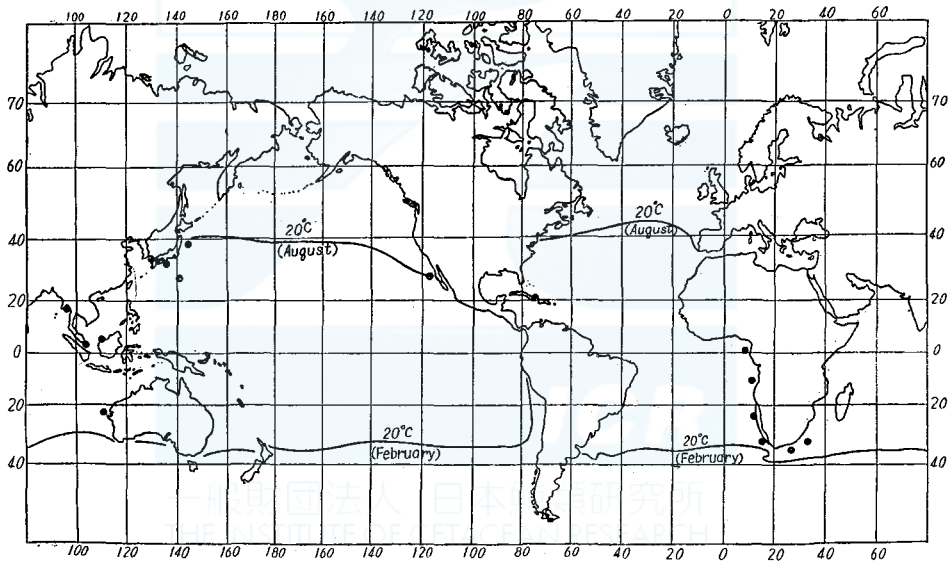

Fig. 10. Showing localities where *edeni* were taken or stranded and 20°C surface temperature of the oceans in August (northern hemisphere) and February (southern hemisphere).

As seen from this Figure all records of occurrence of *edeni*, except from Norway, are within the range between 40°N and 40°S Latitudes, and in the surface water temperature between the isotherms of 20°C in summer in the Northern and Southern hemispheres. We can assume safely, therefore, that the Bryde's whale distribute in tropical and subtropical waters of the world between 40°N and 40°S Latitudes.

SUMMARY

1. From an osteological study it is concluded that the Bryde's whale from the coast of Japan is identical with *Balaenoptera edeni* (=*brydei*) Anderson. The number of vertebrae is 54–55 in our specimens of *edeni*, having 2 more vertebrae than those reported by other authors. But there is a possibility that this is the correct number for this species. The name 'Nitari-kujira' is proposed as the Japanese common name for *edeni*.

2. The external and other characters are reviewed. There is a marked difference in size distribution of the catch between *edeni* and *borealis*, the former being shorter in body length by 4–5 feet.

3. The sei whale (*borealis*) immigrates only to the eastern side of Japan, but *edeni* occurs not only in these waters but also on her south and west coasts.

4. We can assume that *edeni* distribute in tropical and subtropical waters of the world between 40°N and 40°S Latitudes.

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EXPLANATION OF PLATES

PLATE I

Skull of the Ayukawa specimen of *edeni*, 45 feet female
Fig. 1. Dorsal view.
Fig. 2. Ventral view.

PLATE II

Lateral view of the same skull.
Fig. 1. Left side view.
Fig. 2. Right side view.

PLATE III

Skull and mandibles of the same whale.
Fig. 1. Skull. Posterior view.
Fig. 2. Mandibles. Dorsal view.
Fig. 3. Lateral view of the left mandible.

PLATE IV

Vertebrae of the same whale. Lateral view.
Fig. 1. Cervical and dorsal vertebrae.
Fig. 2. Lumbar vertebrae.
Fig. 3. Caudal vertebrae.

PLATE V

Cervical vertebrae and bones of flipper of the same whale.
Fig. 1. Atlas, axis and 3rd cervical. Anterior view.
Fig. 2. 4th-7th cervicals. Anterior view.
Fig. 3. Humerus, radius, ulna, carpals and phalanges in the right flipper.

PLATE VI

Ribs of the same whale.
Fig. 1. Right ribs.
Fig. 2. 1st, 2nd and 3rd ribs of the left side.

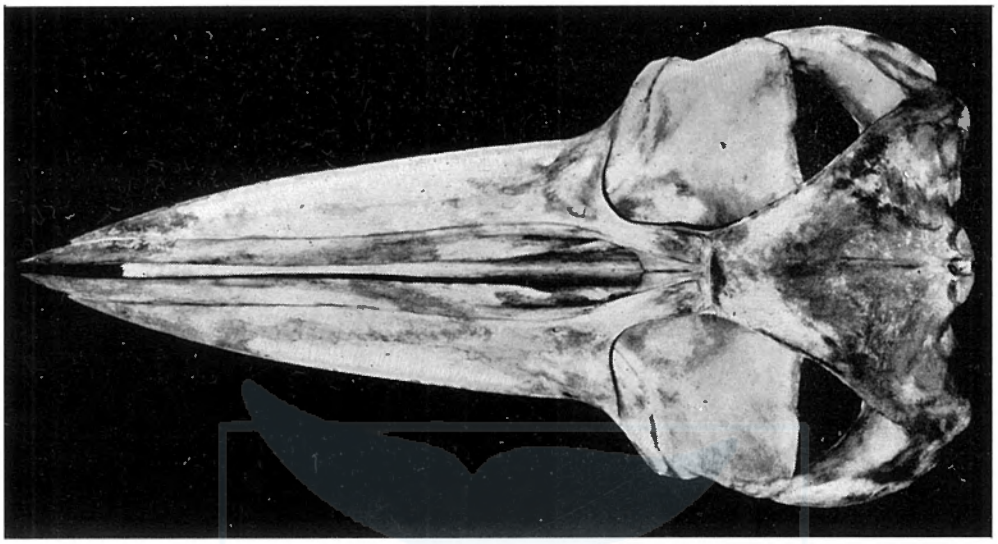

Fig. 1

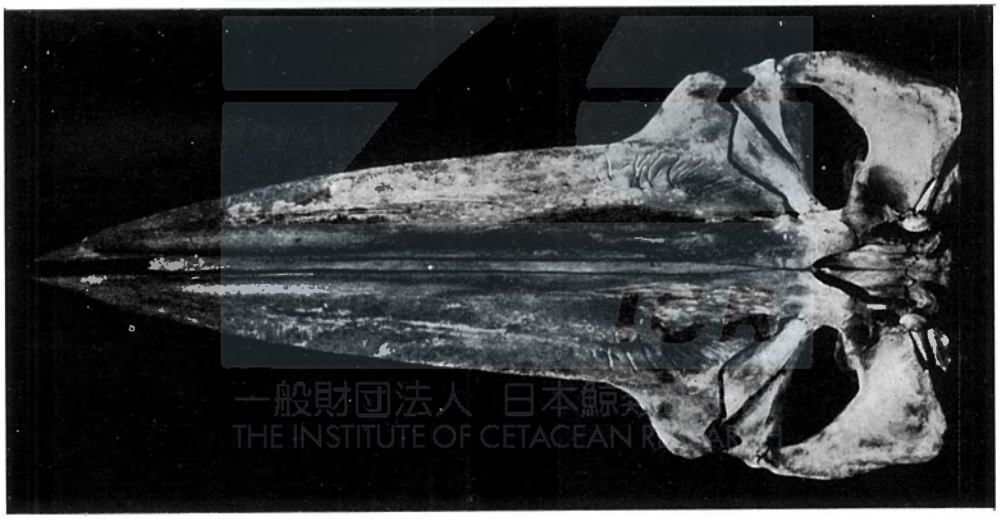

Fig. 2

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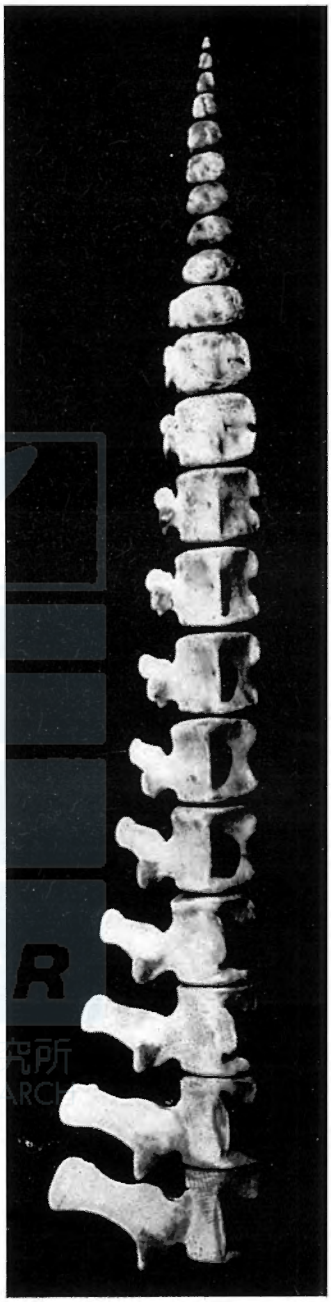

Fig. 3

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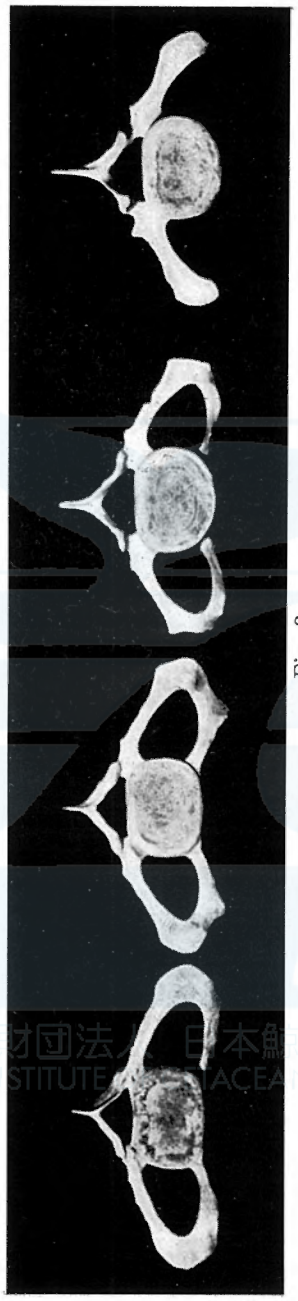

Fig. 2

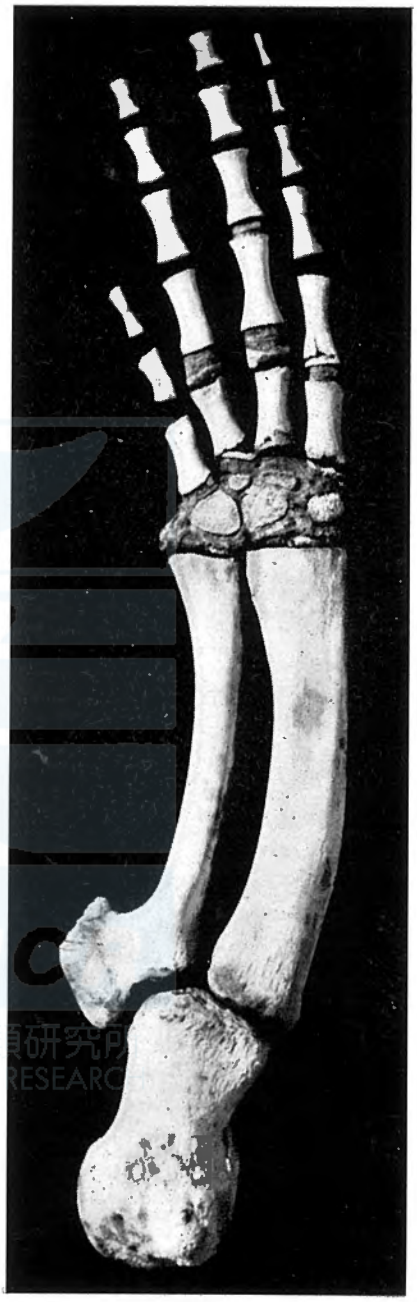

Fig. 3

Fig. 1

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