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Middle Sized Balaenopterid Whale Specimens (Cetacea: Balaenopteridae) Preserved at Several Institutions in Taiwan, Thailand, and India

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Abstract. Twenty-two specimens of middle sized balaenoptrerid whales preserved in 11 institutions in Taiwan, Thailand, and India were examined. We confirmed four specimens of *Balaenoptera acutorostrata*, seven of *B. edeni*, one of *B. brydei*, and ten of *B. omurai*, based on skeletal morphology. These results shed light to hitherto confused systematic understanding of so-called "Bryde's whales". Further studies of both morphological and molecular genetics on specimens, including the holotype specimen of *B. edeni* Anderson, 1879, are strongly expected for the thorough conclusions to be made. The specimen number of these species in institutions might reflect actual distribution density to some extent.

Key words: *Balaenoptera edeni*, *Balaenoptera brydei*, *Balaenoptera omurai*, so-called Bryde's whales, Southeast Asia.

Introduction

Hershkovitz (1966), in his catalog of living whales, listed five species in the genus *Balaenoptera*, namely *B. acutorostrata* Lacépède, 1804, *B. edeni* Anderson, 1879, *B. borealis* Lesson, 1828, *B. physalus* (Linnaeus, 1758), and *B. musculus* (Linnaeus, 1758). Although his taxonomic concept had been accepted widely, a possible existence of an undescribed balaenopterid has been discussed since the late 1990's (Wada & Numachi, 1991). This argument reached a conclusion by the description of *Balaenoptera omurai* Wada, Oishi & Yamada, 2003 and a proposition of validating *Balaenoptera brydei* Olsen, 1913 (Wada *et al.*, 2003). If we make historical review of alterations and discussions on the taxonomy of middle sized balaenopterids, earlier disputes were mainly on discrimination of *B. edeni* from *B. borealis* (Andrews, 1916, 1918), then lumping *B. brydei* with *B. edeni* (Junge, 1950; Soot-Ryan, 1961), and so-called "small

Table 1. Balaenopterid specimens examined in the present study.

Country	Species	Sex	Body length (cm)	Locality	Date	Specimen	Institution*	Registered No. (Field ID)
Taiwan	*B. edeni*	?	1320	Penghu County	1986.01.28	Whole skeleton (articulated)	BCPC	BCPC whale
	B. edeni	M	720	Kinmen County	2001.12.07	Whole skeleton (articulated)	KNP	KINMEN01
	B. edeni	?	?	?	?	Broken skull	TCNHM	—
	B. brydei	F	<1300	Yunlin County	1999.07.31	Whole skeleton (articulated)	NCKU	TN9903
	B. omurai	?	?	Pingtung County	1990.11.05	Incomplete skeleton	NMNS	NMNS1004
	B. omurai	M	554	Tainan County	1997.02.11	Whole skeleton and baleen plates	NMNS	NMNS1931 (TN9707)
	B. omurai	M	513	Miaoli County	1997.03.05	Whole skeleton and baleen plates	NMNS	NMNS2464 (ML9702)
	B. omurai	M	800–900	Taipei County	1997.05.08	Incomplete skleleton	TCM	TP9702
	B. omurai	M	654	Taoyuan County	1998.12.01	Whole skeleton and baleen plates	NMNS	NMNS6619 (TY9802)
	B. omurai	F	595	Hualien County	2004.01.27	Whole skeleton, soft tissues	NCKU	HL20040127
	B. omurai	?	?	?	?	Incomplete broken skeleton	PCAq	PCAQ01
	B. acutorostrata	?	ca 600	Taipei County	1994.01.21	Whole skeleton (articulated)	OWAq	OWAq whale
	B. acutorostrata	M	580	Ilan County	1994.12.24	Whole skeleton	NMNS	NMNS0999 (BK9401)
	B. acutorostrata	M	<500	Taitung County	2001.12.31	Whole skeleton (articulated)	TCM	TD0101
	B. acutorostrata	?	?	Hualien County	?	Broken skull	NTU	NTU01
Thailand	*B. edeni*	?	1200	Trang Province	1994.06.30	Incomplete broken skeleton	PMBC	PMBC11641 (End018)
	B. edeni	?	1300	Phang-nga Province	1994.07.19	Incomplete broken skeleton	PMBC	PMBC11624 (End020)
	B. edeni	F	320	Rayong Province	1996.08.30	Whole skeleton	PMBC	End065
	B. omurai	?	700	Phuket Province	1983.09.15	Whole skeleton (articulated)	PMBC	PMBC11621 (End013)
	B. omurai	M	1000	Phuket Province	1995.06.12	Whole skeleton	PMBC	PMBC11630 (End030)
	B. omurai	F	430	Phang-nga Province	1999.12.01	Whole skeleton	PMBC	End156
India	*B. edeni*	?	1128	Myanmar	1871.06.18	Incomplete skeleton (mounted)	IM	GRM223

* Institution acronyms are as follows:

Taiwan: BCPC(Bureau of Culture, Peng-Hu County); KNP (Kinmen National Park); NCKU (National Cheng Kung University); NMNS (National Museum of Natural Science); NTU (National Taiwan University); OWAq (OceanWorld); PCAq (Peng-Hu Aquarium); TCM (Taijiang Cetacean Museum); TCNHM (Tainan County Natural History Museum). Thailand: PMBC (Phuket Marine Biological Center). India: IM (Indian Museum).

form Bryde's whale" question (Cummings, 1985; Wada & Numachi, 1991; Rice, 1998; Yoshida & Kato, 1999; LeDuc & Dizon, 2002). Recognition of three species of balaenopterid whales of Southeast Asian waters (or Indo-Pacific Ocean) made these taxonomic confusions resolved. Further review works on existing balaenopterid specimens are necessary in addition to sampling activities for the future opportunities of baleen whale strandings and incidental catches.

Materials and Methods

Materials

Specimens examined in this study are listed in Table 1. They are preserved in institutions in Tai-

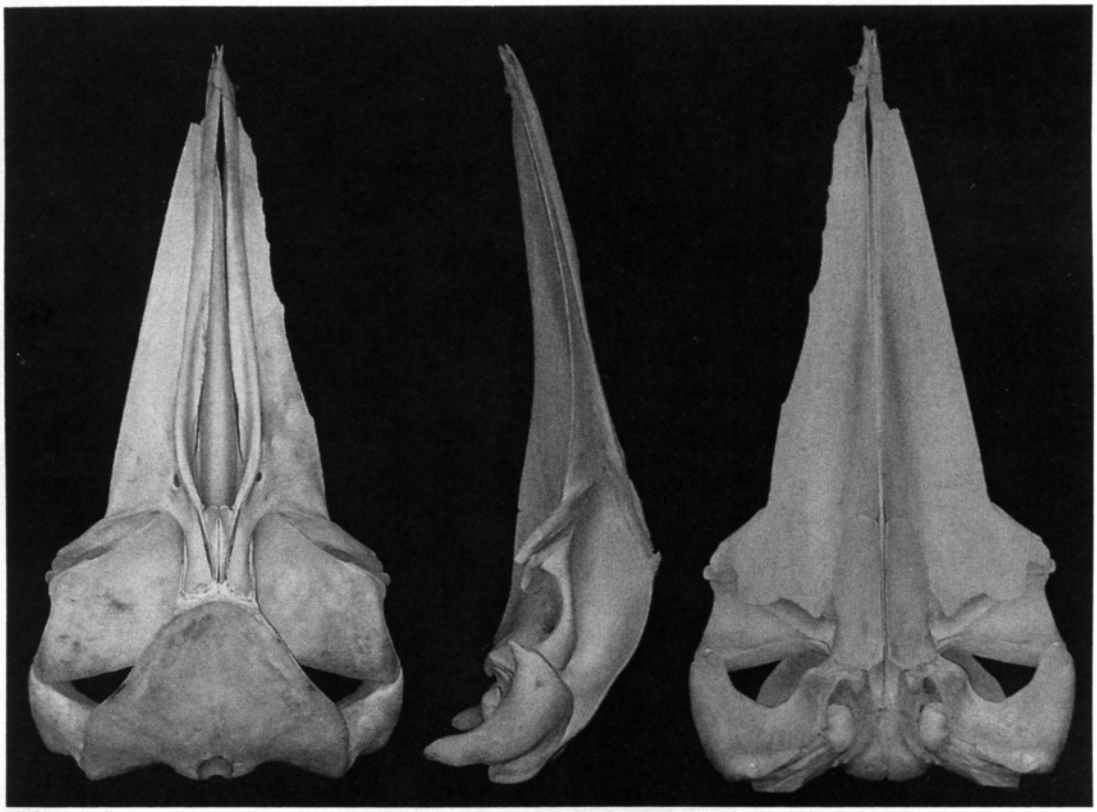

Fig. 1. Dorsal, lateral, and ventral views of the skull of *Balaenoptera acutorostrata* (NMNS0999) in the National Museum of Natural Science in Taichung. These photographs were taken following the standardized protocol we propose (see text). Note right lateral edge of maxilla is damaged.

Table 2. Morphological characters used in the present study for identification of the three middle sized balaenopterid species.

Species	1. Maxilla Ascending Proccess	2. Premaxilla Posterior end	3. Parietal	4. On Parieto-Squamosal suture Foramina	5. Head of first rib
Balaenoptera edeni	slender/round	relatively wide/ reaches frontal	invisible in dorsal view	none	bifurcated
Baklaenoptera brydei	broadens squarishly	slender/reaches frontal	invisible in dorsal view	none	bifurcated
Balaenoptera omurai	broadens squarishly	sinks/becomes invisible posteriorly	visible in dorsal view	two	not bifurcated

wan, Thailand, and India.

In Taiwan, fifteen specimens were preserved in: National Museum of Natural Science (NMNS, Taichung), Taijiang Cetacean Museum (TCM, Tainan), National Cheng Kung University (NCKU, Tainan), Kinmen National Park (KNP, Kinmen), Bureau of Culture, Peng-Hu County (BCPC, Makung), Peng-Hu Aquarium (PCAq, Baisha), OceanWorld (OWAq, Yeh-Liu), National Taiwan University (NTU, Taipei), and Tainan County Natural History Museum (TCNHM, Zuojhen). Six specimens were examined at Phuket Marine Biological Center (PMBC, Phuket) in Thailand and one in India at Indian Museum (IM, Kolkata). Specimens are all skeletons, some of which are broken to various extents. Investigations were made during the periods of Aug. 28 to Sep. 7, 2002 in Taiwan, Mar. 6 to 8, 2003 in Thailand, and Mar. 12 to 14, 2003 in India, respectively.

Characters compared in skeletal morphology

Wada *et al.* (2003), in their original description of *Balaenoptera omurai*, summarized diagnostic characters. Since diagnostic characters for *B. musculus*, *B. physalus*, *B. borealis*, and *B. acutorostrata* (Fig. 1) are obviously distinct, we only discuss disputable three species, *B. edeni* (Figs 2, 3), *B. brydei* (Fig. 4), and *B. omurai* (Fig. 5). We chose following five characters for species identification of above-mentioned three species (Table 2):

Fig. 2. Standardized dorsal, lateral, and ventral views of the skull of *Balaenoptera edeni* (KINMEN01) in the Kinmen National Park. Note posterior end of maxilla is slender and round.

1. Maxilla

Posterior end of the ascending process is slender and round in *B. edeni*, whereas in *B. brydei* and *B. omurai* it widens to become squarish.

2. Premaxilla

Posterior end of the premaxilla is relatively wide and reaches the frontal in *B. edeni*. In *B. brydei*, premaxilla is narrower and comes contact with the frontal. It sinks beneath the maxilla posteriorly and does not reach the frontal in *B. omurai*.

3. Parietal

Both the parietals are invisible in dorsal view in *B. edeni* and *B. brydei*, but widely visible in *B. omurai*.

4. Foramina on the parieto-squamosal suture

There are two small foramina only in *B. omurai* along the suture between the parietal and squamosal in the wall of the braincase.

5. Head of the first rib

The head of the first rib is bifurcated in *B. edeni* and *B. brydei*, but is not bifurcated in *B.*

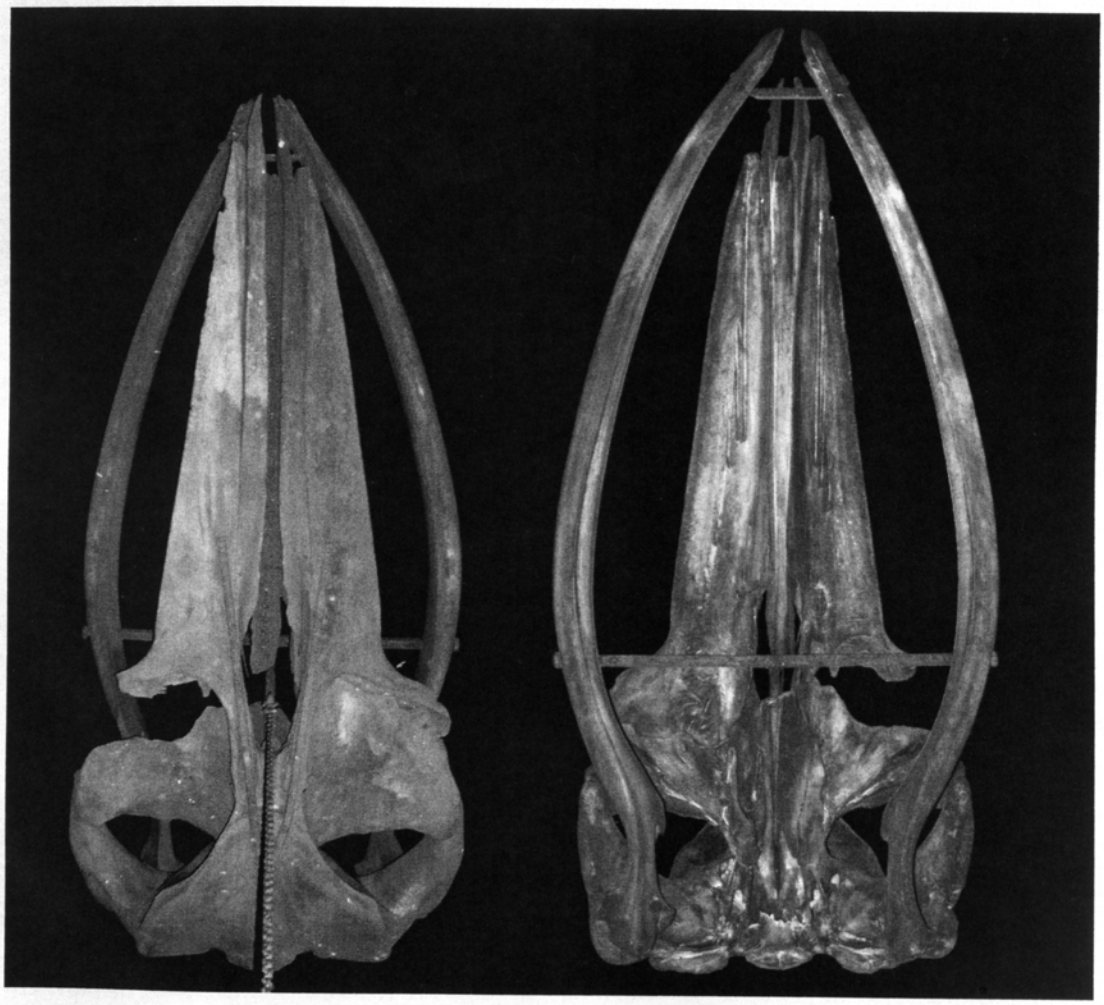

Fig. 3. Dorsal and ventral views of the skull and mandibles of *Balaenoptera edeni* (GRM223) in the Indian Museum. Ventral view was taken according to the standardized protocol, however, dorsal view was taken obliquely from anterior.

omurai.

Standardized skull photography

Photographs of specimens in publications give us abundant morphological information. However, due to the lack of standardized protocol there can be small but not negligible discrepancies, and critical characters, such as relative position of the vertex, are difficult to be discussed. The Frankfurter Ebene (Frankfurt plane) (Martin & Saller, 1957) is a standard plane defined for human skull research based on three measurement points, both the porions and the left orbitale. It is extremely effective for comparative discussions, although it is basically applied within a single genus *Homo*. Standardized plains or axes are thus convenient and effective in discussions of skull morphology. Here, we define the standard position where, firstly the condylo-basal length, i.e., the longitudinal axis of the skull (CB axis) is kept horizontal and then a line connecting the highest points of lateral border of inner surfaces of the both orbits (bi-orbital axis) is also set horizontal. After settling this standardized position of the skull, the superior and inferior views were taken from the points on a line equally bisecting the CB axis and perpendicular to bi-orbital axis, and lateral view was taken from the point on a line equally bisecting the CB axis perpendicularly, and parallel to the bi-orbital axis.

Results

Specimens in Taiwan

Since the 1990's the National Taiwan University, in conjunction with the Taiwan Cetacean Society, have made efforts to collect carcasses of stranded cetaceans, and to prepare and preserve skeletons and soft tissues of these carcasses for exact identifications to species level. Efforts are made to centralize specimen preservation to the National Museum of Natural Science in Taichung whenever circumstances permit.

Researchers in Taiwan had problems in species identification of some of the baleen whale specimens in the collections, because some of the characters are not compatible with those of the known species. We made thorough review of the specimens contrasting with then recognized balaenopterid species (Oishi *et al.*, 2004; Yamada & Chou, 2004). We investigated all accessible specimens in Taiwan including these unidentified ones and identified *B. edeni*, *B. brydei*, *B. omurai*, and *B. acutorostrata* based on the five characters mentioned before.

Fifteen specimens preserved in various institutions in Taiwan were subject to detailed morphological investigation and identified as follows:

Balaenoptera edeni Anderson, 1879

There are three specimens confirmed of this species in Taiwan. They are in the Bureau of Culture, Peng Hu County (BCPC whale, 13.2m, sex not recorded), the Kinmen National Park (KINMEN01, 7.2 m, male; Fig. 2), and in the Tainan County Museum of Natural History (TCNHM, size and sex not recorded).

Balaenoptera brydei Olsen, 1913

There is only one specimen of this species from Taiwanese waters in the National Cheng Kung University in Tainan (TN9903, smaller than 13 m, female; Fig. 4). The skeleton is articulated and on display. The animal is full grown female.

Balaenoptera omurai Wada, Oishi & Yamada, 2003

There are seven specimens of *B. omurai* in four institutions in Taiwan, i.e., four specimens in the National Museum of Natural Science in Taichung (NMNS1004, size and sex not recorded; NMNS1931, 5.54 m, male; NMNS2464, 5.13 m, male; and NMNS6619, 6.54 m, male) and one each specimen in the National Cheng Kung University (HL20040127, 5.95 m, female), the Taijiang Cetacean Museum (TP9702, 8–9 m, male), and the Peng-Hu Aquarium (PCAQ01, size and sex not recorded).

Balaenoptera acutorostrata Lacépède, 1804

The Ocean World (OWAq whale, ca. 6 m, sex not recorded), the National Museum of Natural Science (NMNS0999, 5.8 m, male; Fig. 1), the Taijiang Cetacean Museum (TD0101, smaller

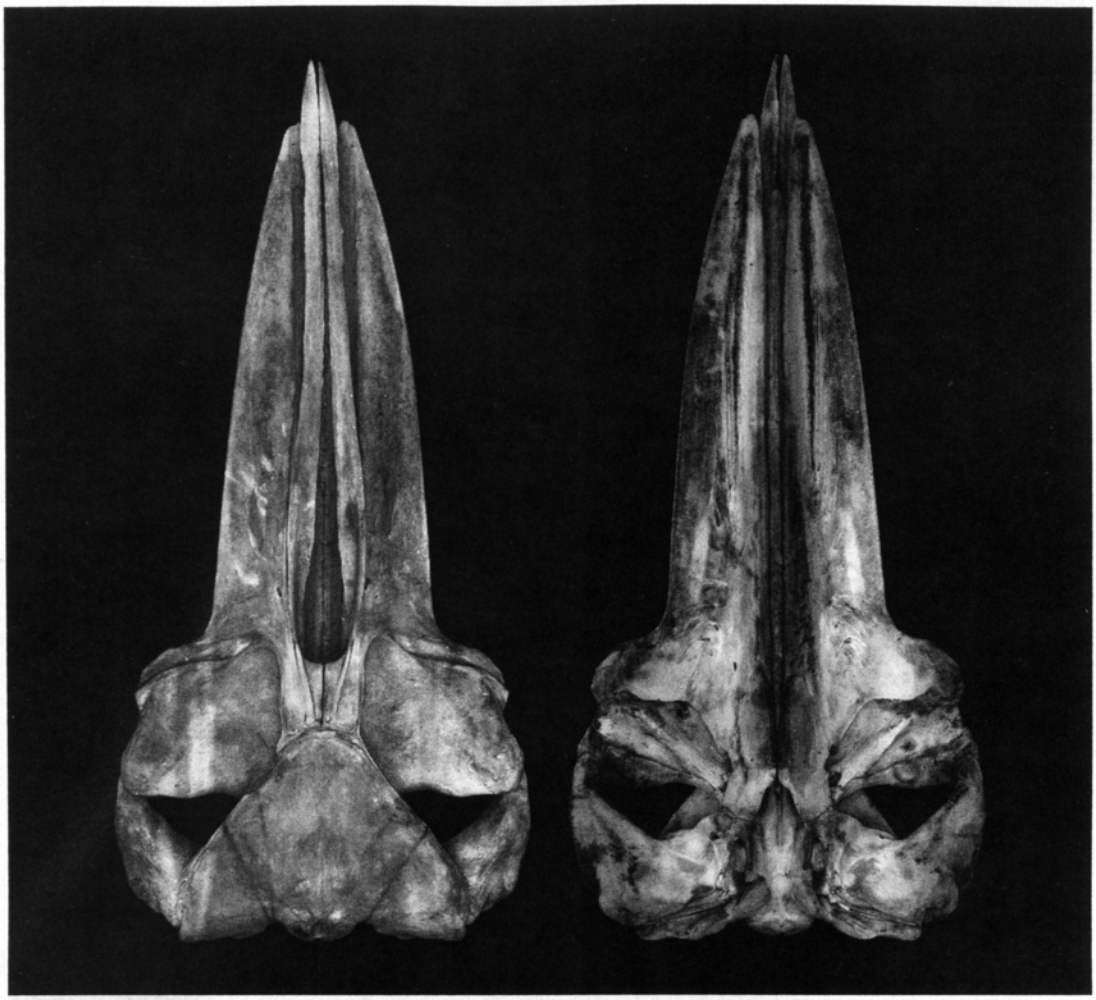

Fig. 4. Standardized dorsal and ventral views of the skull of *Balaenoptera brydei* (TN9903) in the National Cheng Kung University. Note posterior end of maxilla ends wide and squarish, and posterior end of premaxilla is visible all the way and reaches frontal.

than 5 m, male), and the National Taiwan University (NTU01, size and sex not recorded) have one each stranded specimen of this species. There is another whole skeleton of *B. acutorostrata* articulated and exhibited in the National Taiwan University, which was imported from Japan and not included in the present study.

Specimens in Thailand

Marine mammals from the Gulf of Thailand and the Andaman Sea were studied by Pilleri and Gihr (1974), Lekagul and McNeely (1977), Perrin *et al.* (1995), Chantrapornsyl *et al.* (1996), Andersen and Kinze (1999), and Yamada *et al.* (2000). Balaenopterid species known from this area was basically *B. edeni*. Although there are many whale skeletal specimens preserved in Thailand, either in research institutions or in temples, only those preserved in Phuket Marine Biological Center were investigated. A list of stranded marine mammals in Thailand was compiled by Chantrapornsyl *et al.* (1996) and a revision on cetacean specimens in Thailand was made by Andersen and Kinze (1999). Andersen and Kinze (1999) concluded there is an only balaenopterid species *B. edeni* and proposed an English name

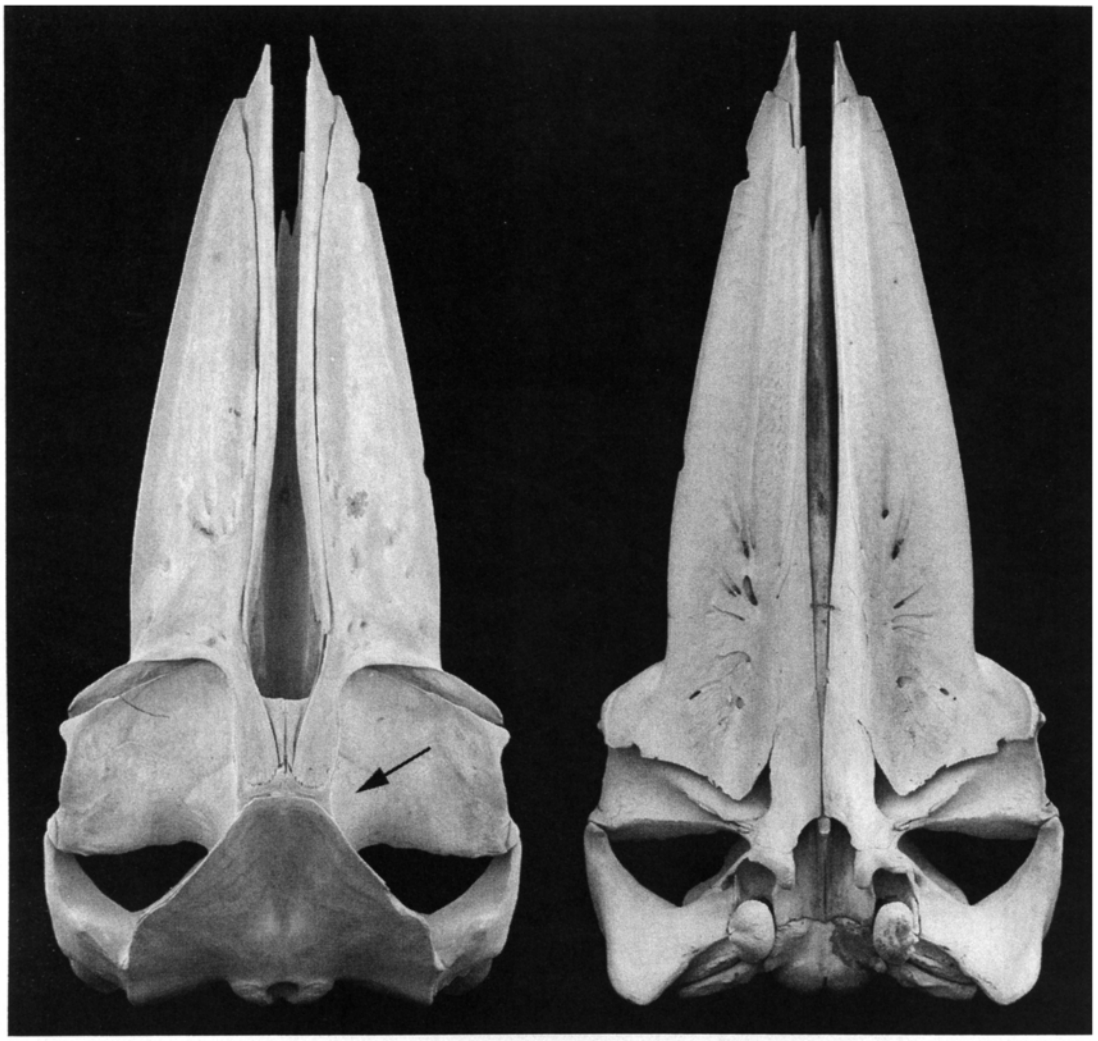

Fig. 5. Standardized dorsal and ventral views of the skull of *Balaenoptera omurai* (PMBC11621) in the Phuket Marine Biological Center. In this species posterior end of maxilla broadens and parietal is clearly visible (arrow) in dorsal view.

of "Sittang whale" for the species.

We reviewed six specimens preserved in Phuket Marine Biological Center and identified three *B. edeni* (PMBC11641, 12 m, sex not recorded; PMBC11624, 13 m, sex not recorded; and PMBC End065, 3.2 m, female) and three *B. omurai* (PMBC11621, 7 m, sex not recorded (Fig. 5); PMBC11630, 10 m, male; and PMBC End156, 4.3 m, female). It is worthy of note that we confirmed *B. omurai* from Thai waters for the first time. It is also interesting that even very young individuals of both *B. edeni* (PMBC End065) and *B. omurai* (PMBC End156) have characters diagnostic for the respective species.

Type specimen of *Balaenoptera edeni* preserved in India

In order to establish detailed skeletal morphology of *B. edeni* we examined the holotype specimen (GRM223; Fig. 3) of this species preserved in the Indian Museum.

Discussion

Systematics of middle sized balaenopterid whales has been in confusion for a long time. Presence of at least two species in so-called "Bryde's whales" was discussed (Junge, 1950; Soot-Ryan, 1961). It was because there are significant differences in skeletal morphology among specimens identified as "Bryde's whale" by presence of three ridges on the head, which was thought as a diagnostic external character for the species. Existence of a species that is similar to "Bryde's whales" in size but not with the three ridges was also discussed since the late 1970's (Wada & Numachi, 1991; Yoshida & Kato, 1999; LeDuc & Dizon, 2002). This species was tentatively termed differently such as "small form Brydes whale" and others by several authors (Wada & Numachi, 1991; Rice, 1998; Yoshida & Kato, 1999; LeDuc & Dizon, 2002). Recognition of four species, *B. edeni*, *B. brydei*, *B. borealis*, and *B. omurai* seems to have clarified this confusion at least in eastern part of Indo-Pacific ocean. Numbers of specimens confirmed in the present study are: four for *B. acutorostrata*, seven for *B. edeni*, one for *B. brydei*, and ten for *B. omurai*. It is noteworthy that the specimen number of *B. acutorostrata* is unexpectedly small, whereas that of *B. omurai* is plenty. Although it is extremely difficult to estimate abundance of each species based on number of specimens in institutions investigated, since the sampling activities could have been at random, these numbers might reflect actual population densities of the respective species in this area to some extent.

Further investigations including molecular genetic studies on existing specimens, especially on the holotype specimen of *B. edeni*, and high resolution photographic database of balaenopterid specimens following standardized protocol are expected.

Acknowledgements

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台湾，タイ，インドの研究施設に保存されている中型ナガスクジラ属鯨類標本

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新井上巳・梅谷綾子・栗原　望

台湾，タイ，インドの研究施設に保存されている中型ナガスクジラ属鯨類標本22点を調査し，骨格の形態学的特徴から，ミンククジラ *Balaenotera acutorostrata* 4点，カツオクジラ *B. edeni* 7点，ニタリクジラ *B. brydei* 1点，ツノシマクジラ *B. omurai* 10点を確認した．1970年代以来議論は提起されていたものの Wada *et al.* (2003) が記載するまで不明瞭であったツノシマクジラの標本点数が相対的に多かったことは特筆に値する．本研究の結果は，これまで混乱が見られたいわゆる「ニタリクジラ類」の分類学的理解を解きほぐすものである．さらにこの混乱を完全に解決するためには，とくにカツオクジラのホロタイプ標本の分子遺伝学的調査が強く望まれる．