

Morphology and distribution of the spinner dolphin, *Stenella longirostris*, rough-toothed dolphin, *Steno bredanensis* and melon-headed whale, *Peponocephala electra*, from waters off the Sultanate of Oman¹

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ABSTRACT

The morphology of three tropical delphinids from the Sultanate of Oman and their occurrence in the Arabian Sea are presented. Body lengths of four physically mature spinner dolphins (three males) ranged from 154-178.3cm (median 164.5cm), i.e. smaller than any known stock of spinner dolphins, except the dwarf forms from Thailand and Australia. Skulls of Oman spinner dolphins ($n = 10$) were practically indistinguishable from those of eastern spinner dolphins (*Stenella longirostris orientalis*) from the eastern tropical Pacific, but were considerably smaller than skulls of populations of pantropical (*Stenella longirostris longirostris*) and Central American spinner dolphins (*Stenella longirostris centroamericana*). Two colour morphs (CM) were observed. The most common (CM1) has the typical tripartite pattern of the pantropical spinner dolphin. A small morph (CM2), so far seen mostly off Muscat, is characterised by a dark dorsal overlay obscuring most of the tripartite pattern and by a pinkish or white ventral field and supragenital patch. Two skulls were linked to a CM1 colour morph, the others were undetermined. It is concluded that Oman spinner dolphins should be treated as a discrete population, morphologically distinct from all known spinner dolphin subspecies. Confirmed coastal range states off the Arabian Peninsula include the United Arab Emirates, the Sultanate of Oman, Yemen, Somalia, Djibouti, Saudi Arabia, Sudan and Egypt.

The taxonomic position of two damaged dolphin calvariae from Oman has been the issue of much debate. This paper discusses the cranial characteristics that allow positive identification as rough-toothed dolphin (*Steno bredanensis*) and melon-headed whale (*Peponocephala electra*) respectively. The calvariae represent the first confirmed specimen records of these dolphin species for the Arabian Sea *sensu lato*.

KEYWORDS: SPINNER DOLPHIN; MELON-HEADED WHALE; ROUGH-TOOTHED DOLPHIN; INDIAN OCEAN; TAXONOMY; DISTRIBUTION; COLOURATION; MORPHOMETRICS; STOCK IDENTITY

INTRODUCTION

Knowledge of the biology, distribution and ecology of most cetacean species in the northwest Indian Ocean is still at an early stage. Strandings, bycatch and sightings records in this region, and especially from the Sultanate of Oman, have been gathered mostly over the past two decades (van Bree and Gallagher, 1978; Gallagher and van Bree, 1980; Alling, 1983; Whitehead, 1985; Gallagher, 1991; Leatherwood *et al.*, 1991; Papastavrou and Salm, 1991; Salm, 1992; Baldwin and Salm, 1994; Mikhalev, 1997; Ballance and Pitman, 1998). Available information has been comprehensively reviewed on a species-by-species basis for small cetaceans of the Arabian Peninsula waters (Baldwin *et al.*, 1998) and for large and small cetaceans in the Arabian Gulf (Robineau, 1998). In May 1996, the authors re-examined the extensive cetacean collection at the Oman Natural History Museum (ONHM), Muscat, Sultanate of Oman, which led to a series of new findings on the morphology, occurrence and taxonomic status of several delphinids from the Arabian Sea.

A preliminary morphological study of distinctive small-bodied spinner dolphins from Oman is presented here. Characterised by cranial morphometrics similar to those of eastern spinner dolphins (*Stenella longirostris orientalis*),

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from the eastern Pacific Ocean (Perrin, 1990), the Oman spinner dolphins show external features quite unlike that subspecies. Two colour morphs are observed, one pantropical and the other atypical. Mörzer-Bruyns (1971) first noted some peculiarities in local spinner dolphins and distinguished them from others as the 'Arabian Dolphin, *Stenella longirostris* subsp.?' . Robineau and Rose (1983) documented in detail a fresh specimen of a small spinner dolphin from the Gulf of Aden.

The morphology of two partly damaged dolphin calvariae from Oman whose identification has caused much confusion over the years is also discussed. They represent the first substantiated specimen records of the melon-headed whale (Gray, 1846) and the rough-toothed dolphin (Lesson, 1828) from Oman and the Arabian Sea.

MATERIAL AND METHODS

From 1969-1990, Gallagher (1991) pioneered the collection of numerous cetacean carcasses and skulls from beaches around the Arabian Peninsula. Those collected after June 1981 are curated at the Oman Natural History Museum (ONHM) and form the basis for this paper. New skeletal material has also been contributed to the collection by various field biologists (including Rod Salm and two of the authors, RB and VP).

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All specimens studied here are from waters off Oman, but for distributional considerations the entire Arabian Sea is covered, defined here as including the Gulf of Oman, Arabian Gulf and Gulf of Aden (for physical features and boundaries see Anon., 1967; 1980).

Skeletons of eight spinner dolphins found stranded on sandy beaches in the southern Gulf of Oman were studied (Table 1). All skulls were mature, as evidenced by distal bony fusion of the premaxillae and maxillae (Dailey and Perrin, 1973; Perrin and Heyning, 1993). Three were males, the sex of the others was not determined. Five of the specimens with postcranial skeletons were physically mature, as recognised by full epiphysial fusion of the vertebrae. Measurements published by Robineau and Rose (1983; 1984) for two additional skulls from Oman (BMNH 1980.872 and 1980.873), held at the British Museum (Natural History), were also used. Another specimen collected in Djibouti (Robineau and Rose, 1983) was juvenile and therefore not included. Despite the small sample, which precludes statistical analysis, preliminary comparative observations are revealing.

A first evaluation of variation in the colour pattern in Oman spinner dolphins is based on numerous at-sea observations by the authors (particularly RB) and a series of colour photographs taken by RB and VP in the period 1990-97. Several photographs have been published (Robineau and Rose, 1984, p.247; Baldwin and Salm, 1994, pp.13, 20, 22, 23, 32, 34; Baldwin, 1995b, pp.27, 97, 1997, 98, 102; 1997, pp.5, 13, 17, 19, 28, 30).

External morphological characters and colouration were scored according to definitions by Perrin *et al.* (1991) and Perrin and Brownell (1994). Perrin *et al.* (1991) defined coded character states for spinner dolphins of the eastern Pacific to indicate the extension of the ventral field (1-5), the presence of a dorsal cape (1-2) and the shape of the dorsal fin

(1-3). The arithmetic total of the code scores for the three characters ranged from 3 (typical adult male eastern spinner dolphin) to 10 (typical adult male pantropical spinner dolphin).

On 1 November 1982, MG extracted an incomplete calvaria from partly buried remains of a dolphin at the high water mark on a beach on Al Hallaniyah island (17°31'N, 56°04'E), in the Kuria Muria Islands (now called Juzor al Halaaniyaat), situated off southern Oman. The calvaria, which lacks a part of its rostrum, is deposited at the Muscat museum under number ONHM 835, and is here identified as a melon-headed whale. Gallagher also retrieved a heavily worn calvaria of a rough-toothed dolphin (ONHM 880) from a hillside at Ra's al Madrasah (19°00'N, 57°50.5'E), Oman, on 2 October 1984. The cranial morphology and particular characteristics which permit a positive identification are discussed in this paper.

SPINNER DOLPHIN

Background

The taxonomy of spinner dolphins (*Stenella longirostris* Gray, 1828), at the level of subspecies and populations is far from settled. Since the first studies of morphological variation (Perrin, 1972; 1975), several new geographic forms have been recognised (Perrin *et al.*, 1989; 1991; Perrin, 1990; Perryman and Westlake, 1998). Except in the eastern Pacific Ocean, this cosmopolitan warm-water delphinid is still not well investigated (Perrin and Brownell, 1994).

Perrin (1990) named and described three subspecies: the pantropical spinner dolphin (*S.l. longirostris*), from the world's tropical oceans; the eastern spinner dolphin (*S.l. orientalis*), from the tropical oceanic and coastal waters of the eastern Pacific; and the Central American spinner

Table 1

Eight specimens of *Stenella longirostris* from Oman examined at Oman Natural History Museum (ONHM), Muscat, and two skulls kept at the British Natural History Museum (BMNH) also referred to by Robineau and Rose (1984).

Cat. number	Locality	Position	Date collected	Sex	SL (cm)	Physical maturity	Comments
ONHM1410	Ra's al Hadd	22°31'N, 59°48'E	Nov. 1989	-	-	-	Skull taken by Glynn Barrett from carcass stranded on the east beach. A few vertebrae exhibited in ONHM Whale Hall, Muscat.
ONHM1728	2km south of Dibab	23°03'N, 59°04'E	28 Dec. 1990	-	-	-	Damaged skull found on rocky beach by MacVentura. Several cranial sutures probably secondarily unfused; premx-mx well fused.
ONHM1735	Muscat, Al Khuwayr beach in front of US Embassy	23°36'N, 58°27'E	14 Feb. 1991	M	154.0	Mature	Found at high tide line of beach by Rod Salm. Posteranials include nine pairs of sternal ribs.
ONHM659	Seeb	23°41'N, 58°12'E	19 Feb. 1987	-	160.0	Mature	Complete skeleton (mounted at ONHM) collected by M. Gallagher at high tide line. Small hump on dorsal tail stock.
ONHM2121	Muscat, Intercontinental hotel beach	23°37'N, 58°28'E	30 Dec. 1992	M	169.0	Mature	Stranded freshly dead with net marks across tail stock; photos available. <i>Legit</i> R. Baldwin.
ONHM1021	Barr al Hikman	20°21'N, 58°27'E	08 May 1987	-	-	Mature	Stranded <i>legit</i> R. Salm and V. Papastavrou.
ONHM1736	North of Azaiba	23°36'N, 58°22'E	16 Feb. 1991	M	178.3	Mature	Stranded with knife wound and blood oozing from mouth; photos at ONHM. Found by R.V.Salm; <i>legit</i> M. Gallagher.
ONHM2106	2km south of Dibab	23°04'N, 59°04'E	14 Nov. 1992	-	-	-	Found on beach at high water mark by M. Gallagher.
BMNH1980-872	Near Sur	22°33'N, 59°40'E	18 Jul. 1977	-	-	-	Beach pick up; collected by M. Gallagher (Gallagher 1991)
BMNH1980-873	Sur Masirah, Masirah Is.	20°25'N, 58°44'E	Dec. 1975	-	-	-	Beach pick up; collected by T.D. Rogers (P.D. Jenkins, Mammal Group, NHM, London, <i>in litt.</i> to MG, 22 Feb. 1999).

dolphin (*S.I. centroamericana*) from the Pacific coastal waters of Central America (Perrin, 1990), and south of the Gulf of Tehuantepec, Mexico (Perryman and Westlake, 1998). The so-called 'whitebelly spinner dolphin' (Perrin, 1972) is now considered to be a hybridisation and an intergradation between the pantropical and eastern subspecies (Perrin *et al.*, 1991; Dizon *et al.*, 1992; Douglas *et al.*, 1992). Another form, most similar to the eastern spinner dolphin, but larger, inhabits inshore Mexican waters north of the Gulf of Tehuantepec and was recently named the 'Tres Marias spinner dolphin' (Perryman and Westlake, 1998). Perrin *et al.* (1989) further recognised a morphologically distinct dwarf spinner dolphin apparently limited to the Gulf of Thailand, but did not proceed to name it formally as a separate subspecies.

Distribution

The distribution of spinner dolphins is more or less continuous from the western Pacific to the Indian Ocean and the Red Sea (reviewed by Gilpatrick *et al.*, 1987; Perrin and Gilpatrick, 1994). They range south in warm waters of the southwest Indian Ocean to about 35°S (Gilpatrick *et al.*, 1987).

Off the Arabian Peninsula, spinner dolphins are encountered in the Arabian Gulf (Mörzer-Bruyns, 1971; Baldwin, 1995a; b), the southern Gulf of Oman and the Arabian Sea coasts (De Silva, 1987; Gallagher, 1991; Baldwin and Salm, 1994), the Gulf of Aden (Robineau and Rose, 1983), and the Red Sea (Leatherwood, 1986; De Silva, 1987).

In the western tropical Indian Ocean, as in the eastern tropical Pacific, spinner dolphins frequently associate with flocks of seabirds and mix with tuna schools (Ballance *et al.*, 1996). This association with tuna had previously been reported off Oman (Salm *et al.*, 1993; Baldwin and Salm, 1994). Artisanal tuna fishermen in the Muscat area exploit this phenomenon by towing baited hooks from small craft at high speed through pods of spinner dolphins (Van Waerebeek and Baldwin, pers. obs.).

Confirmed coastal range states for spinner dolphins around the Arabian Peninsula include the United Arab Emirates, Oman, Yemen, Somalia, Djibouti, Saudi Arabia, Sudan and Egypt. Sub-regional distribution is summarised below.

Arabian Gulf

According to Mörzer-Bruyns (1971, p.74)

'This playful dolphin will always be seen on any voyage to the Persian Gulf, concentrations of thousands have been observed around Ras Fartak and on either side of Strait Hormez';

he further named Kuwait as a range state. Spinner dolphins have been reported (Anon., 1988, not seen, in Robineau and Fiquet, 1996) from the Arabian Gulf, but this is apparently unauthenticated. One of the authors (RB) recently collected skulls on Merawah Island (24°28'N, 53°23'E), Abu Dhabi, United Arab Emirates (Baldwin, 1995a; Baldwin *et al.*, 1998).

Gulf of Oman and Arabian Sea

Records of sightings and strandings indicate a distribution from as far north as the Daymaniyat Islands (23°51'N, 58°05'E), south and east to around Ra's al Hadd (23°31'N, 59°48'E) (Gallagher, 1991; Baldwin *et al.*, 1998); and from Masirah Island (20°25'N, 58°50'E) to Yemen and the Gulf of Aden (14°25'N, 49°32'E) (Alling *et al.*, 1982; Alling, 1986; Gallagher, 1991; Ballance *et al.*, 1996).

Groups of 300 or more spinner dolphins are a frequent sight between Fahal Island (23°41'N, 58°30'E) and Bandar Khayran (23°31'N, 58°44'E) in the Muscat area, especially in March and April (Baldwin and Salm, 1994, p.33). Larger groups of up to several thousand also occur.

An active herd, mixed with common dolphins (*Delphinus* sp.) and totalling several thousand individuals, was witnessed and photographed off Dhofar, southern Oman, on 19 January 1985 by MG and Mohammed Al Barwani. Off Wadi Baqlal (16°56'N, 54°46'E) on 8 May 1992, an active group of 50-80 individuals with young was observed (Salm *et al.*, 1993). Alling *et al.* (1982) reported another three sightings in January 1982: 9 January at 16°45'N, 54°11'E; 13 January at 16°53'N, 54°12'E and 19 January at 18°49'N, 57°47'E (from Oman Cetacean Database).

Such large mixed herds with common dolphins are not infrequent. Associations of spinner dolphins with spotted dolphins, *Stenella attenuata*, have also been seen on two occasions in the Gulf of Oman (Baldwin and Salm, 1994; Baldwin, unpub. data).

Gulf of Aden

Robineau and Rose (1983; 1984) described a 156cm male (MNHN-1981-159) stranded in the Gulf of Tadjoura, in the western Gulf of Aden. Numerous sightings in 1980-81 have been summarised by Robineau and Rose (1984). In Djibouti waters, spinner dolphins are most often encountered at the northern entrance of the Gulf of Tadjoura (between Ras Bir, Ras Duan and the Musha islands) and along the northern coast (from Ras Bir to the Seba and Perim islands in the Bab-el-Mandeb); they are less common inside the Gulf of Tadjoura. They have also been sighted not far from the Arabian Bank (Arab Shoal) (11°40'N, 43°40'E), in the Gulf of Aden, some 50km east of Djibouti.

Spinner dolphins are common off Somalia in the eastern Gulf of Aden and adjacent Indian Ocean inshore areas. Small and Small (1991) positively identified the species 38 times from 1985-87 and plotted the sighting locations (their fig. 5h). Inshore area sightings were in water 10-491m deep and three offshore sightings were in water depths of 475, 116 and 78m (Small and Small, 1991).

Eyre (1995) sighted three groups of spinner dolphins in the eastern Gulf of Aden near Cape Guardafui, Somalia, on 3 July 1993 at 12°14'N, 50°56'E (mixed with bottlenose dolphins, *Tursiops* sp.), 12°16'N, 50°30'E, and at 12°16'N, 50°19'E.

Red Sea

Spinner dolphins are reported near Port Sudan, Sudan (M. Barré, in Robineau and Rose, 1984). There is a spinner dolphin skull in the Field Museum of Natural History, Chicago, collected by D. Osborn on the Egyptian coast north of Marsa Alam (De Silva, 1987). Eyre (1995) sighted six groups in the Red Sea in July 1993 but Beadon (1991), who searched for dolphins to live-capture in the extreme northern portion of the Red Sea including the Gulf of Aqaba and the Gulf of Suez, did not encounter any spinner dolphins.

Skeletal morphology

Skull

Spinner dolphins from Oman have short, narrow skulls, in accordance with their small body size. Cranial measurements are practically indistinguishable from those of the eastern spinner dolphin (Perrin, 1990), except that the specimens in this sample had a slightly longer rostrum (Table 2).

Table 2

Means, sample sizes (round parentheses) and range (square parentheses) for selected skull measurements (in mm) in cranially adult spinner dolphins from Oman, compared to published data for other Indian Ocean specimens and the eastern spinner dolphin (Perrin *et al.*, 1989).

Measurement	Sultanate of Oman	Eastern Pacific	Indian Ocean
	<i>S. longirostris</i> subsp.? This paper	<i>S. longirostris orientalis</i> Perrin <i>et al.</i> , 1989	<i>S. longirostris longirostris</i> Perrin <i>et al.</i> , 1989
Condylobasal length	388.0 (8) [366-424]	386.5 [351-407]	409.2 [394-430]
Rostrum length	248.8 (6) [234-280]	245.5 [218-262]	264.9 [250-281]
Rostrum width at base	73.6 (10) [66-78.5]	72.1 [66-77]	74.0 [71-76]
Rostrum width at 60mm	49.0 (9) [43-54.5]	-	-
Rostrum width at _ length	49.6 (7) [48.5-54]	-	-
Rostrum width at _ length	41.9 (8) [36.1-45]	41.6 [37-47]	43.3 [42-45]
Rostrum width at _ length	30.5 (6) [24.9-35]	30.5 [26-36]	31.0 [28-34]
Width of premax. at _ length	18.8 (7) [17-21.1]	-	19.4 [18-20]
Rostrum tip to external nares	289.3 (9) [267.5-318.5]	-	-
Rostrum tip to internal nares	287.6 (6) [269.5-321.5]	-	-
Preorbital width	133.4 (9) [125-138]	132.3 [127-138]	141.6 [135-146]
Postorbital width	148.9 (10) [139.5-156]	148.1 [140-154]	155.4 [153-160]
Zygomatic width	147.3 (10) [135.5-154]	146.4 [139-153]	154.0 [151-160]
Parietal width	121.7 (10) [112.5-129]	125.9 [119-132]	128.7 [122-133]
Greatest width premax.	59.8 (8) [55-63.5]	-	-
External nares width	38.5 (8) [36-41.3]	-	39.6 [38-42]
Internal nares width	38.8 (8) [35-42]	41.2 [38-45]	42.0 [39-45]
Temporal fossa length	48.2 (10) [43.4-57.5]	48.5 [41-57]	50.0 [46-58]
Temporal fossa width	37.0 (10) [34-41.2]	36.6 [29-47]	41.4 [39-45]
Orbital length	40.9 (8) [39.2-41.5]	39.8 [38-43]	42.3 [40-44]
Antorbital process length	38.3 (8) [34.5-40.5]	39.9 [33-45]	41.7 [40-45]
Upper tooth row length	217.3 (8) [201-247.5]	212.2 [192-229]	232.3 [224-242]
Lower tooth row length	210.6 (8) [192.5-237]	-	-
Ramus length	329.4 (9) [311-366]	329.1 [301-348]	352.0 [336-370]
Ramus height	52.2 (9) [48.7-55.5]	-	-
Upper teeth (per row)	52.2 (6) [50-55]	52.6 [46-61]	52.9 (15) [49-59]
Lower teeth (per row)	49.6 (14) [46-53]	50.5 [45-56]	50.6 (15) [45-58]
Bulla length	28.3 (3) [27.3-29.4]	-	-
Bulla width	16.3 (3) [15.2-17.3]	-	-
Periotic length	26.1 (3) [26.0-26.2]	-	-
Height braincase	91.5 (8) [85-96.5]	86.4 [83-92]	89.7 [88-95]
Length braincase	101.2 (7) [96.5-105.5]	100 [95-108]	102.9 [100-106]

The skulls of Oman spinner dolphins are smaller than those of the Central American spinner dolphin and smaller than the adult skulls of most other known spinner dolphin subspecies and stocks (Table 2, and compare with Perrin *et al.*, 1989). For instance, condylobasal length (CBL) in the Oman spinner dolphins averaged 388mm (range 366-424mm), which is 40mm shorter than in the Central American spinner (428.6mm, 416-439mm) and considerably shorter than all populations of the pantropical spinner dolphin; including those from the Central Pacific (436.9mm, 417-464mm), the Western Pacific (420.1mm, 411-431mm), the tropical Atlantic (427mm, 395-458mm) and an undefined sample from the Indian Ocean (409.2mm, 394-430mm) (Perrin, 1990). Preliminary results suggest that skulls of Philippine spinner dolphins are also larger (Perrin and Dolan, 1996). However, although small, all skull dimensions of Oman specimens exceed, without overlap, those of the Thailand dwarf spinner (342.5mm, 335-352mm; Perrin *et al.*, 1989).

Postcranial skeleton

Cervical vertebrae 3-5 stand free, the atlas and axis are fused. The vertebral formula is variable (Table 3): Cv (2)+ 5; Th 13-14; Lu 19-20; Ca ~ 31 [Lu + Ca, 50-52]; total count, 71-72. Modally there are 14 pairs of ribs, of which five or six pairs are double-headed. The total vertebral count for Oman spinner dolphins is similar to other stocks but slightly higher than the mean (69.7) count for the Thailand dwarf form (Perrin *et al.*, 1989).

External features

Body size

The standard body lengths (SL) of four physically mature spinner dolphins from Oman, including three males and one of undetermined sex, were 154, 160, 169 and 178.3cm (median 164.5cm). These may represent two colour morphs or even (but less likely) two populations (see below).

In the tropical Atlantic, four physically mature males (pantropical spinner dolphins) measured 192-208cm long and two females measured 196cm and 201cm in length respectively (Perrin, 1990). In the Gulf of Mexico, Mead *et al.* (1979) found that adult females averaged 189cm (177-204cm, $n = 17$) and males 193cm (173-208cm, $n = 17$). The average adult length for the pantropical spinner dolphin is about 180-190cm, and the largest animals can reach roughly 215cm (Perrin, 1990). Adult female 'northern whitebelly' spinner dolphins average 171cm, 'southern whitebelly' 176cm (Perrin *et al.*, 1985), while female and male eastern spinner dolphins reach up to 193 and 199cm respectively (Perrin, 1990). Sexually adult Central American spinner dolphins are the largest, ranging from 193 to 216cm

($n = 15$; Perrin, 1990). Only cranially adult males from the Thailand stock (129-137cm, $n = 4$, Perrin *et al.*, 1989) are smaller than our study specimens.

Dorsal fin shape

The dorsal fin shape in all spinner dolphins from Oman is falcate, i.e. congruent with Code 3 (this and subsequent code numbers follow Perrin *et al.*, 1991; Fig. 1).

Colouration

Two colour morphs or phenotypes are seen in Oman waters.

COLOUR MORPH 1

The most commonly encountered type of spinner dolphin off Oman (named here as Colour Morph 1, CM1) shows the typical tripartite colouration of the pantropical spinner dolphin, with a prominent dorsal cape (Code 2) which descends low on the flanks (to about 1/3) and the anterior portion of the ventral field extending dorsally to behind the eye (Code 5). The total code score (= 10) agrees with the pantropical spinner dolphin in terms of external morphology. Most animals do not have post-anal keels as in the eastern spinner dolphin but one large individual was observed with a pronounced ventral keel, near Dibab (*ca.* 23°05'N, 59°05'E), Gulf of Oman, in April 1992.

An adult male was chosen as a CM1 'type' specimen (ONHM 2121, see Table 1 and Fig. 1) for which both the skeleton and original colour photographs of the fresh carcass are deposited at ONHM. Examples of free-ranging animals include Fig. 2 and published photos by Baldwin and Salm (1994, p.32) and Baldwin (1997, pp.4, 17).

A 156cm sexually and physically immature male (MNHN-1981-159) that stranded in Djibouti, Gulf of Aden, agrees with the CM1 morph, but was not examined by the authors. A detailed description, fine drawings (Robineau and Rose, 1983) and a photograph (Robineau and Rose, 1984) have been published. MNHN-1981-159 had a tripartite colouration, a falcate dorsal fin and a hooked flipper apex (Robineau and Rose, 1983), which are also present in the CM1 type. Both dolphins showed black lips, although the lower lip-patch was particularly prominent in the animal from the Gulf of Aden. The flipper stripe in ONHM 2121 merged with the eye-patch, while in MNHN-1981-159 it touched and passed the eye-patch to join the gape of the mouth (Robineau and Rose, 1983), a slight difference which could be explained by individual variation.

COLOUR MORPH 2

This unusual spinner dolphin (Colour Morph 2, CM2) has a fairly indistinct dorsal cape (Code 1) narrowly confined, especially anteriorly, to the spinal region of the dorsum (Fig. 3). At mid-body, the cape dips toward the lateral field,

Table 3

Vertebral formulae for five spinner dolphins *Stenella longirostris* from the Sultanate of Oman (this paper) and one from Djibouti (Robineau and Rose, 1984). (*) = plus one abnormally shaped floating rib.

Specimen	Cv	Th	Lu	Ca	Lu + Ca	Total	Ribs	Double-headed
Sultanate of Oman								
ONHM 1735	(2)+ 5	14	-	-	51	72	14 + 1	5
ONHM 659	(2)+ 5	14	20	>27	>47	~71	14	5
ONHM 2121	(2)+ 5	13	-	-	49 + 2	71	14	6
ONHM 1021	(2)+ 5	13	-	-	52	72	14 (*)	5
ONHM 1736	(2)+ 5	13	-	-	52	72	14	5
Djibouti								
MNHN 1981-159	7	14	19	31	50	71	-	-

reminiscent of the clymene dolphin. A dark dorsal overlay (Perrin, 1972) obscures the basic tripartite pattern, resulting in a grey lateral field occupying most of the anterior body except the throat and a narrow ventral field, which may be pinkish or white. The ventral field exhibits a Code 4 shape (Perrin *et al.*, 1991), with a conspicuous supragenital patch which may be pink-colored. The result is an intermediate pattern between those of eastern spinner dolphins (the obscuring overlay) and pantropical spinner dolphins. CM2 spinner dolphins appear smaller than CM1, however no carcasses have been examined. Unfortunately there is no verification whether or not some of the skeletal material in the ONHM belongs to this form.

A free-ranging dolphin photographed in April 1990 near Fahal Island in the Gulf of Oman is assigned a CM2 'type' (Fig. 3; Baldwin and Salm, 1994, p.34). No ventral keel was present. A small group of dolphins with a white ventral field, photographed in the Gulf of Oman by one of the authors on an unknown date, may also belong to this form.

At-sea observations by the authors indicate that CM2 spinner dolphins do not regularly leap or spin, generally shy away from ships and remain at the surface only for brief moments. Typically, small groups of 20-30 individuals move very fast and are much less approachable than other spinner dolphins. Preferred habitat may be more inshore than for CM1, which could explain why Ballance *et al.* (1996), who surveyed from a large ship, do not seem to have encountered this particular form.

MELON-HEADED WHALE

The melon-headed whale is a mid-sized, pelagic delphinid which occurs throughout the world in tropical and subtropical seas (reviewed by Klinowska, 1991; Mikkelsen and Sheldrick, 1992; Jefferson *et al.*, 1993; Perryman *et al.*, 1994). Coastal surveys of beaches and fishing ports, and shipboard surveys of offshore waters of the Arabian Sea have not yielded any confirmed report of this species (see

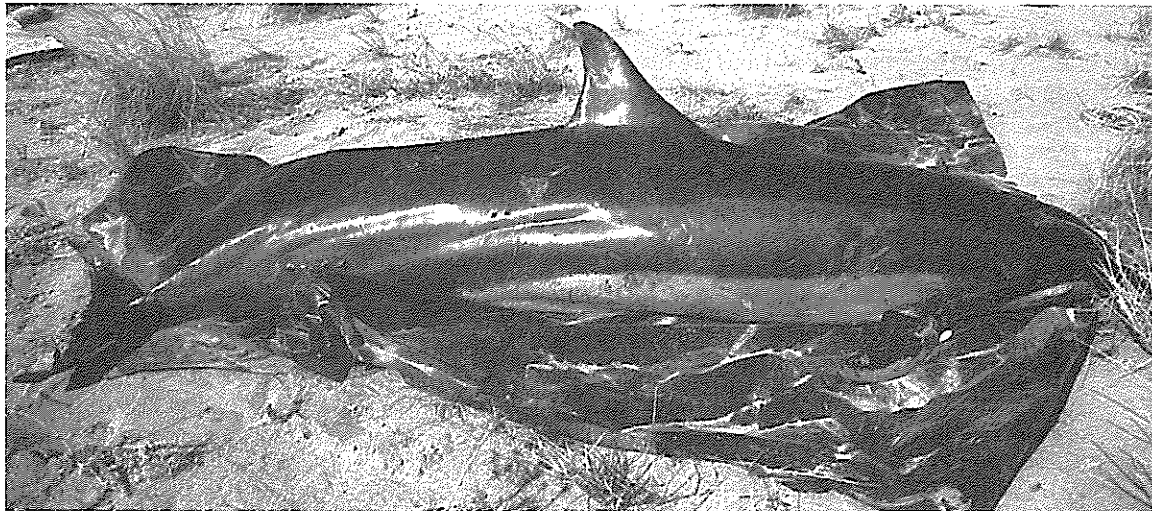


Fig. 1. 169cm male spinner dolphin (ONHM2121) collected by Baldwin on beach, Intercontinental Hotel, Muscat (23°37'N, 58°28'E), Oman, 30 December 1992. Chosen as the CM1 'type' specimen for its clear tripartite pattern, prominent cape and falcate dorsal fin, which identifies it as a pantropical spinner dolphin. Freshly dead, the animal presented cutmarks of nests across the tailstock. Despite its small size, all vertebral epiphyses and cranial sutures were fully fused, evidence of physical maturity. [Photo by Gallagher].



Fig. 2. Two CM1 type spinner dolphins, the most commonly encountered morph off Oman, photographed (by Baldwin) near Fahal Island (23°40'N, 58°32'E), Oman, April 1990. Tripartite colouration is characteristic of pantropical spinner dolphin with prominent dorsal cape descending low on flanks and anterior portion of ventral field extending dorsally to behind eye.

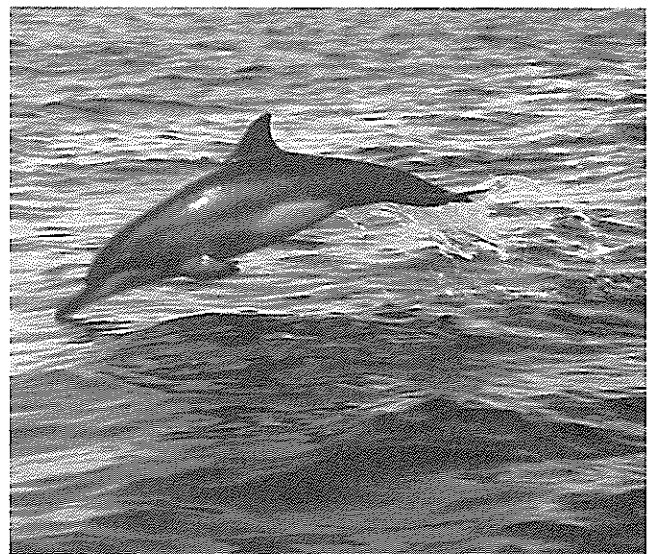


Fig. 3. Smaller than CM1, the CM2 morph is characterised by a dark dorsal overlay obscuring most of the tripartite pattern evident in CM1. Typical pinkish ventral field and supragenital patch (which may also be white) is clearly visible in the colour original of this photograph by Baldwin near Fahal Island (23°41'N, 58°31'E), Oman, March 1990.

Alling, 1986; De Silva, 1987; Gallagher, 1991; Leatherwood *et al.*, 1991; Papastavrou and Salm, 1991; Baldwin and Salm, 1994; Lal Mohan, 1994; Eyre, 1995; Ballance *et al.*, 1996; Robineau and Fiquet, 1996; Ballance and Pitman, 1998). Leatherwood *et al.* (1991, table 9; repeated in Perryman *et al.*, 1994) attributed a sighting of 36 'blackfish' by R.S. Combs on 13 March 1981 at 24°02'N, 58°46'E in the Gulf of Oman to the melon-headed whale. However, the record is not supported by photographs or field descriptions. Due to the difficulty of positive at-sea identification of melon-headed whales, often even by experienced observers (Leatherwood *et al.*, 1988; Van Waerebeek, pers. obs.), it is appropriate to treat this case as an unconfirmed record. Two further unconfirmed records originate from Pakistan (De Silva, 1987):

'... two strandings, one at Cape Monze on 14 October 1981 and the other at Rehri Creek on 20 March 1982'.

Dr Ranjha (cited in De Silva, 1987) claimed melon-headed whales are

'seen regularly off Mekran coast but usually after the end of the monsoon and during the winter months when the Mekran coastal waters provide a particularly rich fishing ground'.

Roberts (1977, p.318, under *Lagenorhynchus electra*) also quoted Dr Ranjha, and added

'No other evidence of its occurrence in Pakistan coastal waters has come to my notice'.

However, the bulbous melon of the poorly known finless porpoise, *Neophocaena phocaenoides*, which inhabits the coastal waters of the northern Arabian Sea from the Arabian Gulf to the Indian subcontinent (Klinowska, 1991; Reeves *et al.*, 1997; Baldwin *et al.*, 1998), may have been mistaken for the similar head of the melon-headed whale.

In the Gulf of Aden, Small and Small (1991) 'positively identified' three melon-headed whales in the inshore waters of the Somali Republic.

Specimen ONHM 835 from Al Hallaniyah island (formerly Khuria Muria), which lacks an estimated 35-40% of its rostrum (Fig. 4), is deposited at the Oman Natural History Museum and had been tentatively assigned by an unnamed scientist to *Tursiops* sp. (listed in Gallagher, 1991). A careful re-examination permitted us to attribute it to the melon-headed whale. The combination of the following cranial features (modified from Nishiwaki and Norris, 1966; Dawbin *et al.*, 1970; Mikkelsen and Sheldrick, 1992), clearly recognisable in ONHM 835, are diagnostic for the melon-headed whale and distinguish it from other delphinids including its closest phenotypic relative, the pygmy killer whale, *Feresa attenuata* Gray, 1874:

- (a) in dorsal aspect, the premaxillaries in the rostrum are flat and positioned at the same level as the maxillaries [these are raised in e.g. *Tursiops* and *Grampus*];
- (b) presence of deep antorbital notches [these are shallow in *Tursiops*];
- (c) external nares are bordered rostrally by the maxillae which emerge triangle-shaped between the premaxillae;
- (d) in lateral view, the maxillae posterior to the antorbital notches appear S-shaped, due to their closely lining the curvature of the orbits (frontale);
- (e) presence of a wide palatal ridge;
- (f) paired premaxillar foramina are located anterior to the most anterior pair of maxillar foramina; exceptionally the right premaxillar and maxillar foramina are almost at the same level [premaxillar foramina are located

posterior to the anterior maxillar foramina in the pygmy killer whale; $n=9$, KVV-032 in Peruvian Centre for Cetacean Research, Pucusana, Peru; Yamada, 1954; Fraser, 1960; Nishiwaki *et al.*, 1965; Perrin and Hubbs, 1969; Bryden, 1976];

- (g) the left external naris in dorsal view shows a markedly larger aperture than the right external naris.

Characters (a), (b), (c), (e), and to a much lesser degree (d), are also found in pygmy killer whale but characters (c), (f) and (g) are absent. Moreover, the premaxillar borders in pygmy killer whale strongly indent on the proximal half of the rostrum where the premaxillae reach their least width (see Ross and Leatherwood, 1994). The melon-headed whale shows only the faintest hint of a premaxillar indentation, or none at all as is the case in ONHM 835 (Fig. 4).

Selected cranial measurements of ONHM 835 are: smallest width of rostrum at base, 121mm; preorbital width, 213mm; postorbital width 225.5mm; zygomatic width, 220mm; parietal width, 173mm; greatest width of premaxillaries, 80.5mm; external nares width, 55mm; internal nares width, 65mm; temporal fossa length, 86.5mm; temporal fossa width, 56mm; orbit length, 63mm; antorbital process length, 39.5mm; height braincase, 130mm; length braincase, 132mm. Alveoli are eroded and cannot be counted. All major skull sutures are unfused but due to the obvious signs of beachwear, cranial maturity cannot be determined with any certainty. The zygomatic width in eight adult skulls of melon-headed whales ranged between 234-277mm (Dawbin *et al.*, 1970; Bryden *et al.*, 1977). Therefore we suggest that specimen ONHM 835 is almost certainly subadult.

The Al Hallaniyah calvaria represents the first confirmed record of the melon-headed whale from Oman and the first authenticated specimen record for the Arabian Sea.

ROUGH-TOOTHED DOLPHIN

The rough-toothed dolphin is another oceanic cetacean, found in tropical and warm-temperate seas around the world, whose regional distribution is poorly documented (Klinowska, 1991; Miyazaki and Perrin, 1994). Until this delphinid was sighted twice off Oman's central coast (Ballance *et al.*, 1996; Ballance and Pitman, 1998) during a US National Oceanographic and Atmospheric Administration (NOAA) cruise in March-July 1995 (five animals at 22°44'N, 59°54'E on 19 July 1995; about ten animals at 23°16'N, 59°04'E on 20 July 1995), the species was long suspected but unconfirmed for the Arabian Sea.

Other published but unsupported accounts of rough-toothed dolphins from the Arabian Sea include: 'strandings observed on Pakistan coast' (Mohd. Farooq Ahmad, pers. comm. in De Silva, 1987; no voucher data), equivalent to 'Pakistan coast' in Miyazaki and Perrin (1994). There has been no verification of these accounts.

Miyazaki and Perrin (1994) indicated on a map (their fig. 1) a record from western India; W.F. Perrin (pers. comm. to Van Waerebeek, 10 Dec. 1998) stated that it originated from an unpublished source who, he added, may have been the late Dr. Steve Leatherwood. If so, it must be post-1986 since the Leatherwood (1986) catalogue of Indian Ocean cetaceans does not mention a record from western India. Unpublished sources were also likely to be the basis of the three Gulf of Aden records, apparently sightings, mapped in Miyazaki and Perrin (1994). Hershkovitz (1966) also cited the species 'from the Gulf of Aden' with no elaboration, thus precluding verification.

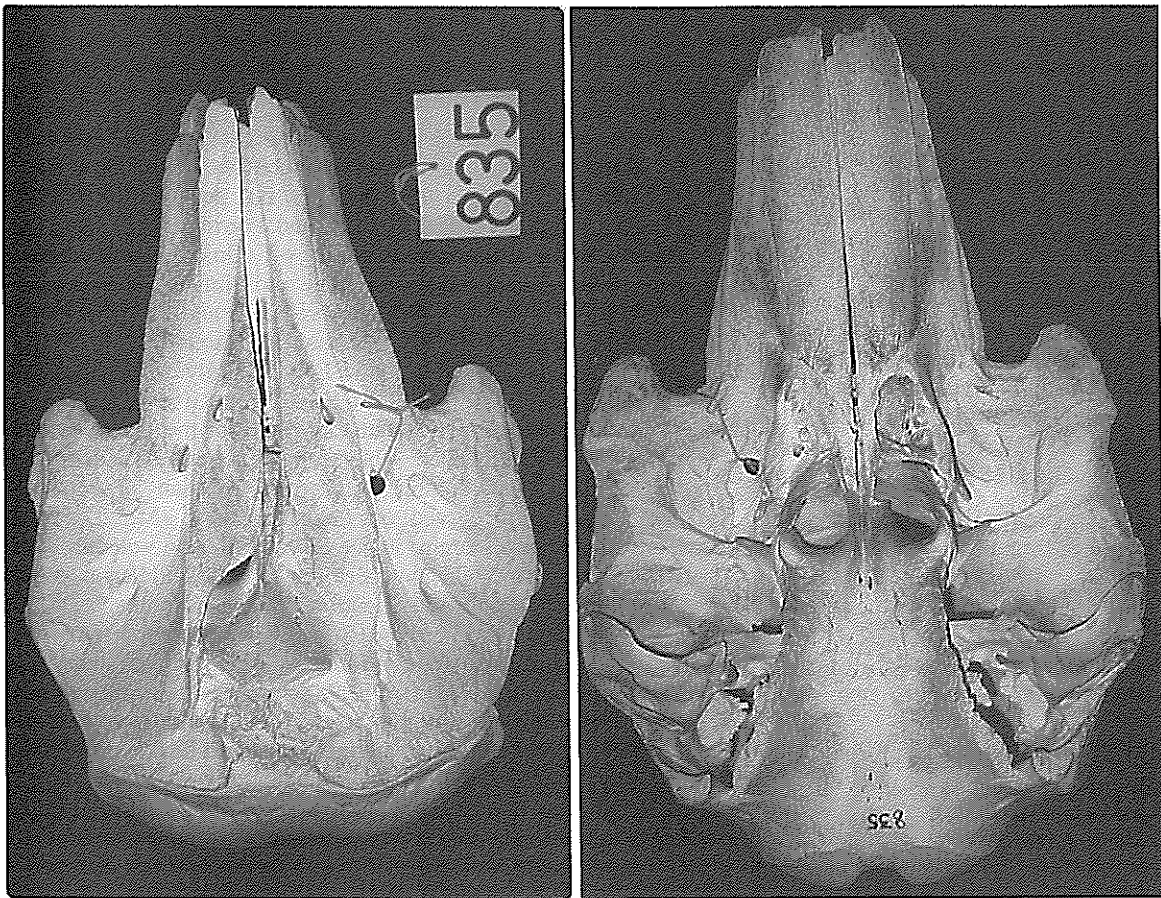


Fig. 4. (Above). Dorsal and ventral aspect of calvaria ONHM 835, found on a beach by Gallagher at Al Hallaniyah island, southern Oman, in November 1982. [Photo by Van Waerebeek].

Fig. 5. (Right). Ventral, dorsal and lateral aspect of calvaria ONHM 880, collected from a hillside at Ra's al Madrakah, October 1984. Arrows indicate the cylindrical ridges on the ventral side of the frontal (see text). [Photo by Van Waerebeek].

Dolphin calvaria ONHM 880 from Ra's al Madrasah was provisionally classified by an unnamed scientist as *Tursiops* sp. (listed in Gallagher, 1991); the Indo-Pacific hump-backed dolphin, *Sousa chinensis* (Osbeck, 1765), has also been suggested. However, based on its distinctive characteristics (Fig. 5), we positively identify the specimen as a rough-toothed dolphin. This species can readily be distinguished from *Tursiops* spp. and most other delphinids by the very large temporal fossa, concave external borders of the maxillaries in the anterior half of the rostrum and the wide premaxillaries. The rough-toothed dolphin can be differentiated from the Indo-Pacific hump-backed dolphin, which commonly occurs in Omani waters (Gallagher, 1991; Papastavrou and Salm, 1991), based on two cranial characteristics:

- (1) a prominent and long cylindrical ridge, straight or slightly bent anteriorly, on either side of the ventrolateral aspect of the frontale, forming a 45° angle with the skull axis and mesially touching the pterygoid (see Fig. 5; compare with fig. 4 in Miyazaki and Perrin, 1994). Relief on the ventrolateral aspect of the frontale in 30 intact Indo-Pacific hump-backed dolphin skulls from Oman, studied at the ONHM, was neither cylindrical nor prominent and was highly curved. The same applies to six skulls of Atlantic hump-backed dolphins, *Sousa teuszii* (Kükenthal, 1892) examined at the Institut Fondamental d'Afrique Noir (IFAN) in Dakar, Senegal (Van Waerebeek, unpub. data);
- (2) alveoli are noticeably bigger and more widely spaced in the rough-toothed dolphin (one-sided upper tooth count range: 19-26, Miyazaki and Perrin, 1994) than in the Indo-Pacific hump-backed dolphin from Oman and the western Indian Ocean (range: 31-38, Ross *et al.*, 1994; Van Waerebeek, Gallagher and Baldwin, unpub. data).

The partial upper left alveolus count was 14 in specimen ONHM 880 for an estimated 70% of rostrum intact (Fig. 5). Therefore we estimate the complete UL tooth count before damage to have been about 20, certainly not exceeding 25. This is considerably less than the minimum tooth count of 31 for any known hump-backed dolphin from the western Indian Ocean (see above).

An additional specimen was examined, consisting of a pair of dolphin mandibles (without collection number) with 25 tooth alveoli in both the left and right ramus at the Marine Science and Fisheries Centre of Muscat, Oman. Accompanying voucher data were lacking, but the rami were collected beyond any reasonable doubt on the coasts of Oman. The typical rugose tooth enamel and conical shape of the teeth (Neuville, 1928), as well as the tooth count (range for one mandibular ramus: 19-28, Miyazaki and Perrin, 1994) identified this specimen as a rough-toothed dolphin. The relatively short mandibular symphysis (compared to adults) was consistent with the specimen being a juvenile. This mandible and calvaria ONHM 880 constitute the first specimen records of rough-toothed dolphin for Oman and the Arabian Sea.

DISCUSSION

Although additional samples are needed for statistical comparison, Oman spinner dolphins evidently show a combination of morphological features that differ substantially from other known populations, and for which they deserve at least separate population status. Their adult

body size is apparently smaller than all described subspecies and stocks, with the exception of dwarf forms from Thailand and northern Australia (see Perrin *et al.*, 1989; Perrin and Dolar, 1996). Craniometrics are practically identical to those of eastern spinner dolphins, although Oman spinner dolphins may have a slightly longer rostrum.

The CM2 colour morph shares with eastern spinner dolphins a dark overlay system (although not as extensive) obscuring the tripartite base pattern, in contrast to pantropical spinner dolphins. CM2 animals, however, most notably differ from eastern spinner dolphins in that adult males do not have canted dorsal fins or pronounced ventral keels and many individuals typically show a pinkish or white supragenital patch.

The CM1 morph combines the colouration pattern and body shape of the pantropical spinner dolphin with the cranial features of the eastern spinner dolphin, but it does not show hybrid features or values intermediate between these subspecies.

The taxonomic status of CM1 and CM2 morphs remains uncertain. Also, the relationship between the two colour morphs cannot be satisfactorily explained at this point due to shortage (CM1) or absence (CM2) of well-documented specimens. While it cannot be positively excluded, we believe the observed morphs are not the expression of sexual or age-dependent variation. If that were the case, social group segregation would be complete, because CM1 and CM2 have not been seen together and schools of the two forms appear to behave differently. In addition, both a physically immature and a mature male CM1 dolphin have been examined, implying that if the CM2 type (smaller) are juveniles, then not all juveniles necessarily exhibit the CM2 pattern.

The pronounced dark dorsal overlay in CM2 may be equivalent to the heavily pigmented (melanised) form of the dusky dolphin, *Lagenorhynchus obscurus*, which co-exists with lightly pigmented animals within the same population off Peru, although sometimes separated in different herds (Van Waerebeek, 1993). If so, we are observing little else but extensive individual variation. Future data should shed light on this question.

The peculiar pink-bellied colouration of some CM2 spinner dolphins raises a question about their kinship with the '*dauphins a ventre rose*', specimens of which were brought back from the Moluccan Sea (between Celebes and New Guinea) by Dumont D'Urville (1842-1853, pl.22) and formally named *Delphinus roseiventris*, Wagner, 1846. This nominal species has been synonymised with an unspecified spinner dolphin stock (Hershkovitz, 1966; Perrin, 1990; Robineau, 1990). Perrin (1990) originally thought the *D. roseiventris* holotype (MNHN 1882-104) to be a small skull (CBL 384mm, ZYW 153mm) from the Moluccas, kept in the Paris Natural History Museum. However, Robineau concluded that supporting evidence is needed and that no *D. roseiventris* holotype can be identified with any certainty. He therefore chose as lectotypes skull No. A3026 and postcranial skeleton No. 1883-553, both from dolphins caught in the Moluccas in March 1839 (Robineau, 1990; *in litt.* to Van Waerebeek, 12 March 1998). This material needs to be compared with the Oman specimens.

A 175cm female from off Calicut, western India, pictured in Lal Mohan (1985: his figures 1D and 2B), was morphologically very similar to CM1 Oman spinner dolphins, with a falcate dorsal fin and without a pronounced ventral keel. Lal Mohan (1985) had reported unusually large sizes for spinner dolphins, up to 252cm, but this may be equivocal or a non-standard measurement.

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