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An Osteological Study of the Dugong *Dugong dugon* (Sirenia) from India

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Abstract

An osteological study of the dugong (sea cow) *Dugong dugon* (Müller) from India, based on complete skeletons of an adult male and a juvenile female indicated certain morphological variations with age. It has also revealed a close osteological similarity between the dugongs from India and the Red Sea. Based on a statistical analysis, regression equations for certain typical skull measurements have been calculated; these equations, characteristic of the dugong from India, could be used for comparing dugongs of different regions.

Introduction

Opinions differ as to whether or not the dugong or sea cow *Dugong dugon* (Müller) constitutes a single species throughout its entire range of distribution. Only fragmentary information is at present available from different localities due to the non-availability, for study purposes, of adequate material of this comparatively rare and interesting animal. The dugong is often caught along the Palk Bay and the Gulf of Mannar coasts in the south-eastern region of India. A few reports on the occurrence and habits of *Dugong dugon* (Müller) have been published earlier (Jones, 1959; Mani, 1960; Silas, 1961; Mohan, 1963), and much valuable information on its biology and behaviour has been provided by a pair of captive dugongs kept alive in the Aquarium of the Central Marine Fisheries Research Institute, Mandapam Camp (Jones, 1967). However, an osteological study of the dugong from the Indian region has so far not been reported. In order to compare the osteological characters of the dugong from this region with those of dugongs from other regions with a view to aiding in eventual clarification of the species problem, a detailed study of the dugong skeleton was made; the results are presented in this paper.

Earlier works on the skeletal features of the Sirenia in general or on dugongs from particular localities include those of Sedgwick (1905), Beddard (1902), Parker and Haswell (1940), Petit (1955) and Gohar (1957).

Material and Methods

The material examined in this study consists of two complete skeletons of an adult male (275 cm long) and a young female (106 cm long; length measured from snout tip to tail fork) captured from the Gulf of Mannar. The male was caught near Hare Island (9.4 km from Mandapam) on the 14th September, 1965 and the female at Valai Island (21.7 km from Mandapam) on the 9th December, 1965. In addition to the above, 12 skulls ranging from 262 to 384 mm in condylobasal length, several vertebrae and pectoral girdles collected from coastal areas of the Gulf of Mannar and the Palk Bay, and three skulls, 376 to 384 mm in condylobasal length, available at the Bombay Natural History Society, Bombay, were also studied.

The two complete dugong skeletons were prepared by removing the greater part of the flesh whilst still fresh; the bones were then placed in boiling water for about 3 h to soften adhering tissues, and finally cleaned and dried in the sun.

Fourteen morphometric measurements were taken from the skulls of seven males and 10 females (Table 1). A few (Specimens 1 to 14, Table 1) were selected for further statistical analysis to determine possible sex differences.

The angle of deflection of the premaxillaries was determined by pressing a flexible wire on the dorsal surface of the skull to obtain the natural contour. Then, the wire was placed on a paper and a few points noted along its course. These were joined to give the angle of deflection of premaxillaries with reference to the dorsal surface of the skull (Table 1).

Osteology

Skull

The skull is massive, heavy, elongate and characteristically hard. The anterior third is very narrow and bent downwards at an angle ranging from 120° to 136° (Figs. 1 and 2). The premaxillaries are long, with their anterior portions deflected downwards (Figs. 1 and 2). The bent anterior portion of each premaxillary contains a large cavity, 12 cm long, 3.5 cm wide, which holds the

16.5 cm-long tusk. The exposed part of the tusk measured 4.5 cm in the large male specimen. The premaxillaries are separate. The posterior portions of the premaxillaries curve round, forming a large median cavity. At the posterior extremity they articulate with the lacrymals, which are small, flat bones. The frontals are fused into a single bone with two lateral, wing-like, anterior extensions. The paired nature of the frontals is indicated by a small median anterior suture. The

Table 1. *Dugong dugon*. Skull measurements

Skull no.	Condylo-basal length (mm)	Palatal length (mm)	Muzzle. width (mm)	Interorbital constriction (mm)	Postorbital constriction (mm)	Zygomatic width (mm)	Condyle width (mm)	Exoccipital width (mm)	Premaxillary length (mm)
1	354	225	84	146	144	221	99	155	199
2	153	90	27	74	76	122	48	89	83
3	307	180	60	122	130	187	broken	136	156
4	262	156	54	114	115	171	81	131	141
5	355	238	78	164	160	234	97	149	199
6	384	246	84	174	168	219	97	150	218
7	324	210	74	133	138	203	92	152	190
8	337	192	63	146	139	194	broken	146	186
9	361	245	75	171	178	233	102	156	172
10	337	218	74	150	151	212	102	151	187
11	330	213	76	151	152	208	91	150	192
12	365	231	78	157	156	225	broken	140	197
13	295	176	53	133	124	182	broken	broken	148
14	356	231	83	161	163	236	97	157	202
15	376	220	75	162	156	221	broken	broken	195
16	376	248	82	173	175	234	99	144	250
17	384	217	81	145	150	210	broken	broken	196

parietals are fused into a single, flat postero-median bone. At the back of the skull, the foramen magnum is surrounded dorsally by the supraoccipital, laterally by the exoccipitals, ventrally by the basioccipital. The occipital condyles are prominent. The upper margin of the supraoccipital is arched, and on its surface is a median ridge with two lateral depressions. The union of the exoccipitals and the basioccipital is complete. The zygomatic arch is formed by the large squamosal and the jugal

Lower jaw length (mm)	Mandible length		Nasal cavity width (mm)	Premaxillary thickness (mm)	Angle of deflection of rostrum	Teeth[a]	Sex
	Straight part (mm)	Deflected part (mm)					
272	205	107	71	73	127°	1+3 / (1+4)+2	Male
122	99	38	40	20	136°	2+3 / (1+3)+3	Female
206	156	70	69	49	129.5°	2+4 / (1+3)+4	Female
not available	not available	not available	55	37	124°	2+4 / no lower jaw	Female
not available	not available	not available	72	61	125°	1+2 / no lower jaw	Male
278	217	92	76	80	127°	1+3 / (1+3)+2	Male
264	200	104	63	62	121°	1+3 / (1+3)+2	Male
246	184	92	69	49	120°	2+4 / (1+3)+4	Female
not available	not available	not available	73	60	121.5°	1+3 / no lower jaw	Male
not available	not available	not available	78	56	124.5°	1+3 / no lower jaw	Male
265	192	90	74	65	122°	1+2 / (1+3)+3	Male
268	211	100	72	58	125.5°	1+3 / (1+3)+2	Female
not available	not available	not available	68	43	134.5°	2+4 / no lower jaw	Female
275	210	112	76	62	121°	1+2 / (1+3)+2	Female
266	190	125	80	56	no data	1+5 / (1+3)+4	Female
298	226	119	76	61	no data	1+2 / (1+3)+2	Female
280	204	109	75	60	no data	1+3 / (1+3)+3	Female

[a]Number of incisors (or their sockets) is followed by molars on one side of each jaw. The values in parentheses indicate, respectively, the number of anterior and posterior incisors (or their sockets) in lower jaw, on one side. Specimens 15 to 17, from the Bombay Natural History Society, are presumed to come from northern region of Arabian Sea; 15 and 16 labelled M5971 and M5970, 17 dated 18.8.1959.

bones. The bones can be separated easily at the point of articulation. The infraorbital foramen is formed by portions of the maxillary and the jugal, the latter bone constituting only a small portion of the anterolateral and posterolateral corners. The ventrolateral portion of the squamosal provides, on each side, an articular surface for the condyloid process of the lower jaw. The maxillaries are large, and bear teeth posteriorly. On each side there are three teeth, the anteriormost smallest, the posteriormost largest and shoe-shaped. The maxillaries articulate in front and

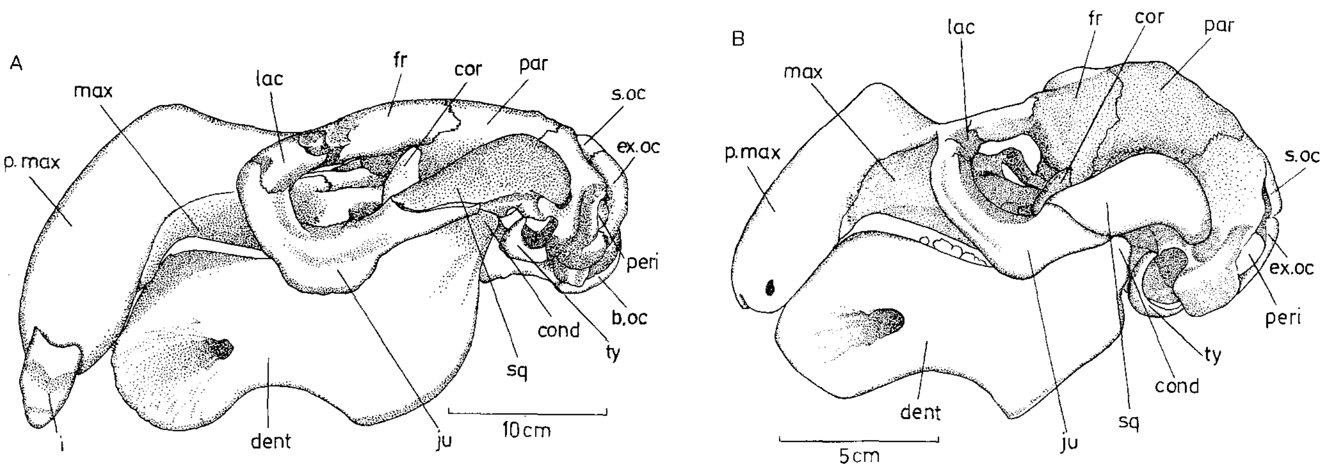

Fig. 1. *Dugong dugon*. Lateral view of skull of (A) adult male, (B) juvenile female. b.oc: Basioccipital; cond: condyloid process of mandible; cor: coronoid process of mandible; dent: dentary; ex.oc: exoccipital; fr: frontal; i: incisor; ju: jugal; lac: lacrymal; max: maxillary; par: parietal; peri: periotic; p.max: premaxillary; s.oc: supraoccipital; sq: squamosal; ty: tympanic

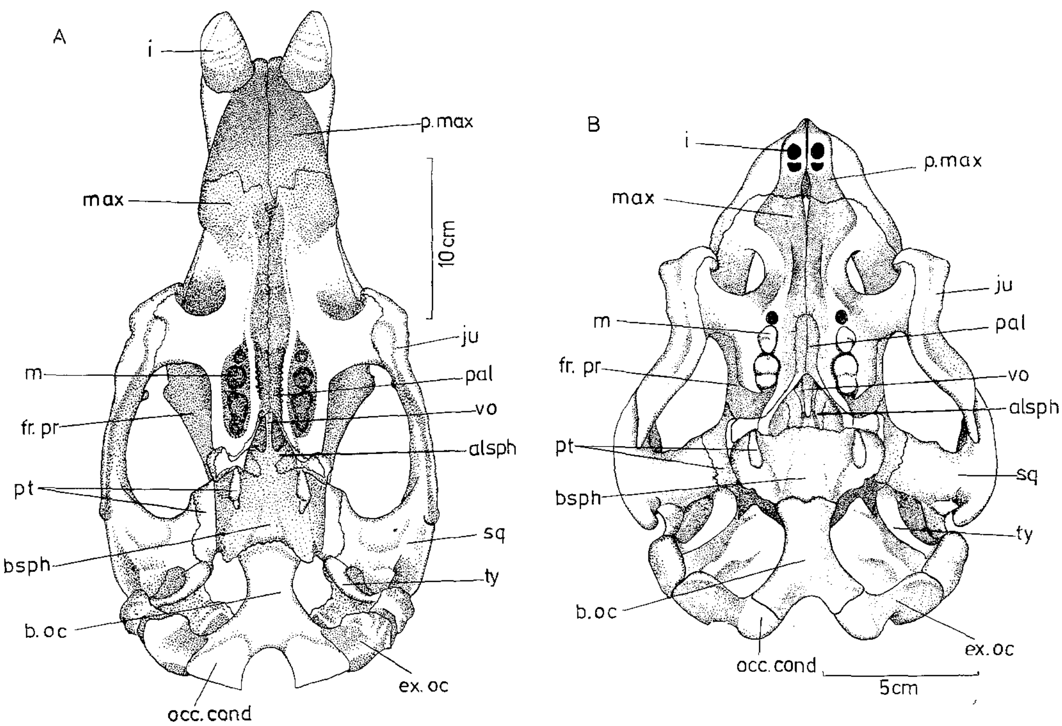

Fig. 2. *Dugong dugon*. Ventral view of neurocranium of (A) adult male, (B) juvenile female. alsph: Alisphenoid; bsph: basisphenoid; fr.pr: frontal process; m: molar tooth; occ.cond: occipital condyle; pal: palatine; pt: pterygoid; vo: vomer. Other abbreviations as in Fig. 1

above with the premaxillaries, laterally with the jugals, posteriorly with the palatines. They also enclose a groove along the median line, in front of the teeth. The palatines are small bones, the anterior ends of which are horizontal. The anterior extremities of the palatines are at about the same level as the first pair of rudimentary teeth. The posterior portions of the palatines are vertical, and articulate with the basisphenoid. The sutures between the palatines themselves and between these and the jugals are very wavy. The basisphenoid articulates behind with the basioccipital; at their point of union, a bulbous projection is present in the posteroventral region of the skull. Distinct sutures are visible where the pterygoids unite with the palatines, but these are not seen where they unite with the basisphenoid. Each pterygoid bears a ventromedian process representing portions of alisphenoid, basisphenoid and palatine. The vomer is a narrow median bone articulating behind with the basisphenoid, below with the anterior ends of the palatines, and in front with the maxillaries. The nasals are absent. The alisphenoids are situated on either side of the base of the vomer. The sutures of union with the adjoining bones are indistinct.

The auditory capsule is formed by the massive periotic bone and the ring-like tympanic bone, the latter supporting the tympanic membrane. The tympanic cavity is open, with the auditory aperture situated below the posterior end of the zygomatic arch.

The lower jaw is formed on each side by the dentary, with prominent coronoid and condyloid processes posterodorsally, and an imperceptible angular process posteroventrally. The middle portion of each dentary bears 3 prominent molars; the anterior small, the middle larger and round, the posterior shoe-shaped. In the large dugong skeleton, the socket of the first molar is 4.7 cm deep and 1.6 cm wide, that of the second 4.7 cm deep and 2.2 cm wide. The anterior portions of the dentaries are deflected downwards, and are flattened to support the horny pad on the lower jaw.

Below the horny pad are 4 cavities on the right side and 5 on the left side (in the larger skull) for lodging the rudimentary lower incisors. The pair at the anterior tip of the lower jaw is widely separated from the posterior pair. Only one pair of rudimentary incisors is present in the second pair of cavities. The anterior end of the right incisor was visible from the side. The anterolateral side of the lower jaw bears a foramen which is connected to a groove anteriorly. There are two such grooves on the right side. The foramen proper ends internally at the base of the posterior molar.

Pectoral girdle

The scapula is a large curved bone, broad on top and narrow below. The glenoid cavity is large. The spine is situated at about mid-length, and the acromion process is directed downwards. The cora-

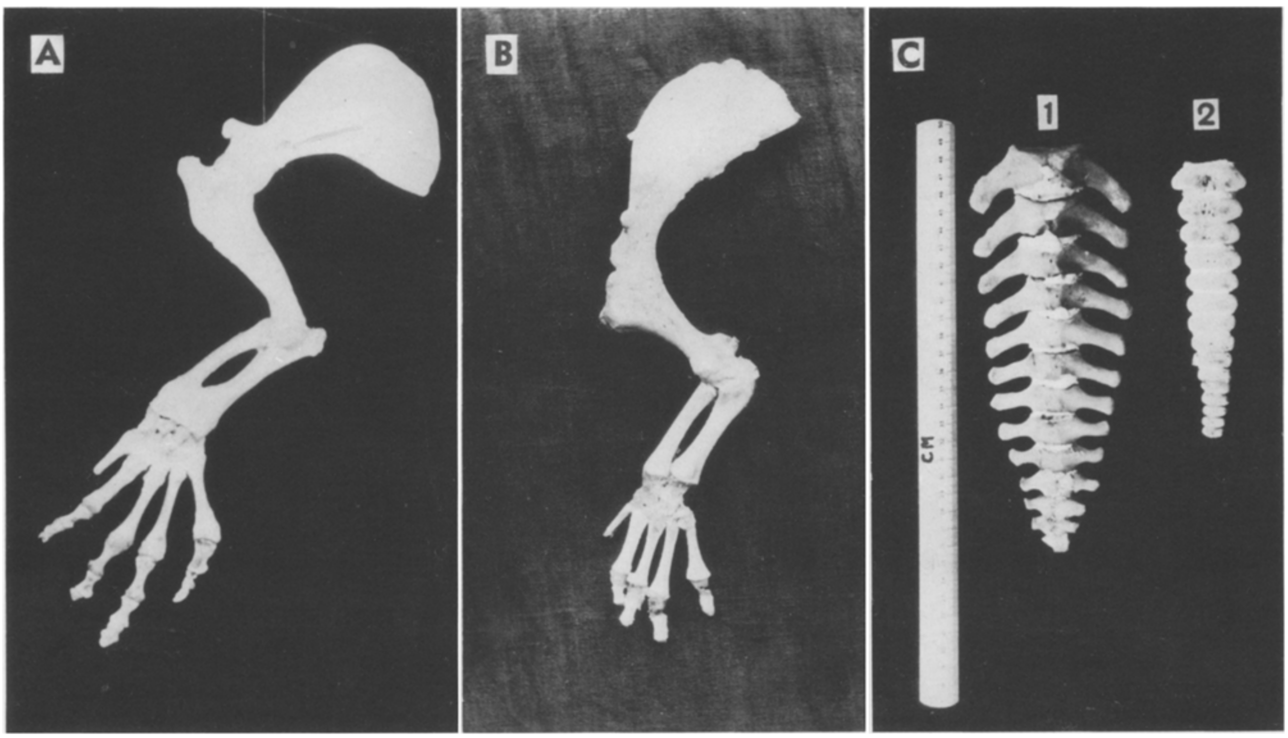

Fig. 3. *Dugong dugon*. Fore limb with pectoral girdle of (A) adult male, (B) juvenile female. (C) Posteriormost vertebrae of adult male (1) and juvenile female (2), dorsal views

coid is curved and points downwards. The clavicles are absent (Fig. 3).

Fore-Limb

The humerus is a strong, irregularly curved bone, broad and flat on top and narrow below. At the upper end of the humerus there are 4 processes or tuberosities on the external side and two — including the head of the humerus — on the internal side. At the lower end there is only 1 internal process. The radius and ulna are united at their extremities; they gently curve to form a long, narrow passage between them. The articular surface is contributed more by the radius than the ulna, which extends beyond the upper part of the radius and covers the lower part of the humerus. The united portion of radius and ulna is narrow on top and broad below, the latter part providing articulation for two of the carpal bones.

The carpal bones are 3 in number — 2 proximal, 1 distal to radius and ulna. The distal carpal articulates with the 2 proximal ones. The external proximal carpal (directly opposite to the ulna) has a process extending downwards, the posterior surface of which provides articulation for the fifth digit. The distal carpal bone provides articulation for the first 4 digits.

There are 5 digits, the metacarpals and phalanges of which are connected by well-formed joints (Fig. 3). The first digit is a single curved bone (Metacarpal I), broad proximally and narrow distally. While articulating with the carpal bone, a portion of its top on the external side provides an articular surface for the second metacarpal. The second digit consists of 1 rod-like metacarpal and 3 flattened phalanges, the metacarpal being the longest and the phalanges progressively decreasing in length distally. The third digit articulates partly with the distal carpal bone and partly with the upper end of the metacarpal of the second digit. A small, narrow gap exists within the articular facet of the second metacarpal and the carpal bone, and a wider gap between the articular facets of the second and third metacarpals. The third digit consists of 1 metacarpal and 3 phalanges, and is longer than the second — all its phalanges and metacarpals being longer. The fourth digit is the longest of the series, consisting of 1 metacarpal and 3 phalanges. The metacarpal is narrow proximally, broad and compressed distally. Its proximal end is narrower and its distal end broader than the corresponding portions of metacarpals of the preceding two digits. In general, the phalanges of the fourth digit are more compressed than all preceding ones. The fifth digit consists of 1 metacarpal and 3 phalanges and articulates with the facet provided by the proximal external carpal bone. The proximal portion of the metacarpal bears a small articular facet on the inner side which articulates with the top of the metacarpal of the fourth digit. The phalanges of the fifth digit curve inwards, the whole digit thus describing an inward bend. They are more compressed than those of the preceding digit. The proximal and distal ends of the metacarpal are broader than those of the corresponding segments of the preceding digits.

Except in the case of the first and fifth digits, the metacarpal of the other digits bears articulating surfaces on either side of its proximal end for articulation with its neighbours. The last phalanx (in some cases, the penultimate also) of all digits is irregular in shape.

Sternum

The sternum consists of a single piece of bone, with a short anterior median process (presternum) and a long posteromedian process (xiphisternum) which is bifurcated at the tip. The middle portion of the sternum is flattened, giving rise to 5 pairs of cartilaginous ribs.

Pelvis

The pelvis is rudimentary, represented by an elongate, curved bone on each side, narrow on top and broad below. The bone is attached on each side below the tips of the transverse processes of the 30th vertebra, in an inclined position.

Hind limbs are altogether absent.

Vertebral Column

The vertebral column consists of 57 acoelous vertebrae divisible into 4 regions, i.e., the cervical containing 7, the dorsal (thoracic) 18, the lumbar 6, and the caudal 26 (Fig. 4). A clear demarkation between the last two regions is, however, difficult. The number of lumbar vertebrae for the dugong is generally fixed at 3 (Petit, 1955).

The first or "atlas" vertebra has 2 bean-shaped lateral facets anteriorly for articulation with the occipital condyles. Posteriorly, it has 2 lateral bean-shaped facets and a median basal, oval facet articulating with 3 similar facets on the anterior side of the second vertebra (axis). The odontoid process of the axis is prominent, resting on the central portion of the base of the atlas. Posteriorly, it shows 2 lateral spinous projections directed outwards. The posterior articular facet of the axis is large. There is only a slight indication of transverse processes on the 3rd vertebra. Its neural arch has 2 elevated facets laterally for articulation with the upper spinous projections of the 2nd vertebra. The second pair of projections of the second vertebra do not articulate with the 3rd vertebra. Above the transverse process of the 3rd vertebra, a complete foramen (costotransverse foramen) is formed on the right side, but is incomplete on the left side. The neural arch of the 3rd vertebra is not completely fused on top, while that of the 2nd is completely fused. Above the transverse processes of the 4th vertebra the foramina are complete on either side, the neural arch being incomplete. The 2 pairs of posterior processes visible on the 2nd vertebra are prominent on the 3rd also; on the 4th, only the upper pair is prominent, the lower pair contributing to the foramina with the transverse processes. The neural arch of the 5th vertebra is complete, and the transverse processes bear 2 downwardly directed processes. These processes are not prominent on the 6th vertebra. The 3rd, 4th, and 5th cervical vertebrae bear the costotransverse foramina. The neural arch of the 6th vertebra is complete, its dorsomedian joint being distinct. No foramina are visible above the transverse processes of the 6th vertebra. The 7th vertebra is similar to the 6th, but with a completely fused neural arch and 2 additional posterior ventrolateral facets for articulation with the first rib, in conjunction with 2 similar half facets on the anterior side of the 8th vertebra.

The dorsal level of the second vertebra is higher than that of the first, but that of the successive vertebrae up to the 7th gradually decreases as one vertebra fits below the other. Although the 8th vertebra also fits below the 7th, the neural arch is fairly raised compared to those in front of it. From the 9th vertebra onwards the articular facets between 2 vertebrae are more or less parallel on either side. From this vertebra onwards, 2 prominent posterior projections (postzygapophyses) fit into concavities in a similar position on the next vertebra. From the 13th vertebra, the postzygapophyses of the preceding and succeeding vertebrae providing articulation on either side become more acute. From the 31st vertebra onwards, the postzygapophyses are completely absent, whereas the prezygapophyses are prominent and are directed upwards. However, there is a slight indication of the postzygapophyses on the left side of the 32nd vertebra. This difference in the prominence of pre- and postzygapophyses also corresponds to the division of the vertebral column, i.e., the precaudal and postcaudal divisions. The prezygapophyses are distinct up to the 40th vertebra, from whence they gradually merge with the centrum up to the 46th vertebra, beyond which there is no trace of them.

The chevron bones are well developed, typical in structure and are distinct from the 32nd to the 41st vertebra. They articulate between two successive vertebrae.

The centra of the cervical vertebrae are characteristically thin and plate-like. From the 8th vertebra onwards they are thick and circular up to the 44th vertebra. They are triangular in section from the 45th to the 50th vertebra. The rest of the centra are dorsoventrally flattened

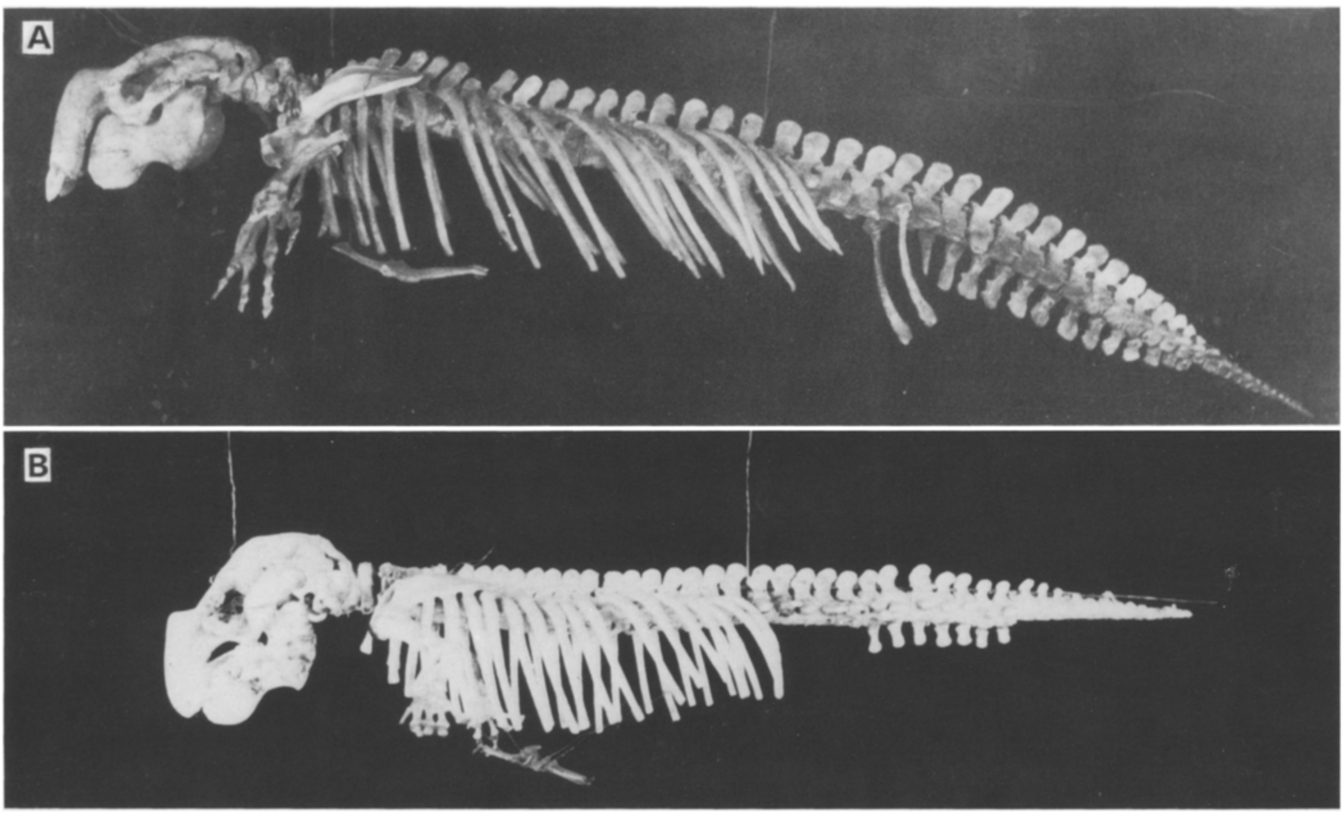

Fig. 4. *Dugong dugon*. Lateral view of complete skelton of (A) adult male, (B) juvenile female

(Fig. 3C). The centra of almost all vertebrae from the 8th onwards show ventrolateral concavities. Throughout the vertebral column, between two centra, an intervertebral disc is present to facilitate the bending of the vertebral column.

The neural spine is prominent from the 8th to the 44th vertebra. Complete neural arches are present from the 8th to the 47th vertebra. However, rudiments of the neural arch are also visible in the 48th and the 49th vertebrae. The first complete haemal arch is found on the 32nd vertebra, which marks the beginning of the caudal vertebrae. There is no trace of a haemal arch from the 45th to the 47th vertebra.

The transverse processes are prominent from the 26th to the 53rd vertebra. The last 4 vertebrae also bear them, but appear as mere lateral extensions only (Fig. 3C). The transverse processes of the 40th to 53rd vertebra are rod-like with truncate tips, while in front of the 40th vertebra they are dorsoventrally flattened with blade-like tips. The tips of the transverse processes of the 26th and 27th vertebra are joined laterally.

Ribs

The thoracic vertebrae (8th to 25th) bear the 18 pairs of ribs. Vertebrae 7 to 14 have double joints for ribs, and the remaining vertebrae only single joints. In the former case, the capitulum of the rib articulates with two successive centra and its tuberculum articulates with the transverse process of the corresponding vertebra only.

The first rib is more or less straight and cylindrical; from the second onwards, the ribs are curved — the 2nd to 4th ribs are compressed while the rest are cylindrical. The tips of the anterior 12 pairs of ribs are truncate, those of the last 6 pairs pointed. From the 5th rib onwards, a protuberance is present at about the mid-length of the rib. These protuberances, which are directed backwards, are more conspicuous on the 14th, 15th, and 18th pairs of ribs.

Teeth

The upper incisors (tusks) project prominently in the male, but are scarcely visible outside in the female. Their bases, which are outcurved, are located at the top of premaxillaries. In the skull of the adult male (condylobasal length, 354 mm) and also in all the other large skulls (condylobasal length, 262 to 384 mm), there is 1 socket on each side of the skull; in the smallest skull (condylobasal length, 153 mm), 1 pair is visible on each side (Fig. 2). In all the skulls, the lower incisors are rudimentary, and are covered by the horny plate. In the majority of skulls, even the abortive teeth are not visible and the cavities are filled up by bony lamellae. In one of the skulls, one pair of lower incisors was found which are rod-like and curved anteroventrally.

A maximum of 3 molars are present on each side in both jaws. The first 2 are usually small, the last (both upper and lower) elongate and shoe-shaped in some specimens. The molars have no roots nor enamel, and possess tuberculated crowns which wear down to flat surfaces. While most of the molars (the portions lying in the sockets) are curved outwards, a few may be curved backwards and others may be straight. The dental formula may be written as

$$i \frac{1-2}{4-5} m \frac{3}{3} .$$

The variation in the number of teeth in the skulls examined is given in Table 1.

Comparison of the Adult with the Young Skeleton

Detailed examination of the skeleton of the young juvenile female (106 cm long) revealed several interesting differences from that of the adult (274 cm) described above (Table 2).

To study the change, if any, in the angle of deflection of premaxillaries with growth, the angle of deflection of premaxillaries was plotted against the condylobasal length of the skull. It is evident from the scatter diagram that the angle is greater in the young dugong than in the adult.

Statistical Analyses of Skull Measurements

In order to study the relationship between the condylobasal length of the skull and body length in *Dugong dugon,* the condylobasal lengths of the two skulls for each of which the corresponding length of the body is known were plotted against each other. The condylobasal lengths of all the other skulls, were also plotted; all formed a straight line with the first two points (Fig. 5), indicating that the relationship is simple and direct. This relationship may be useful to determine the length of the body if the condylobasal length of the skull is known and vice-versa. Lack of more data, however, make determination of the exact mathematical relationship impossible.

Of the 14 morphometric measurements made for the skulls, the following 8 were statistically

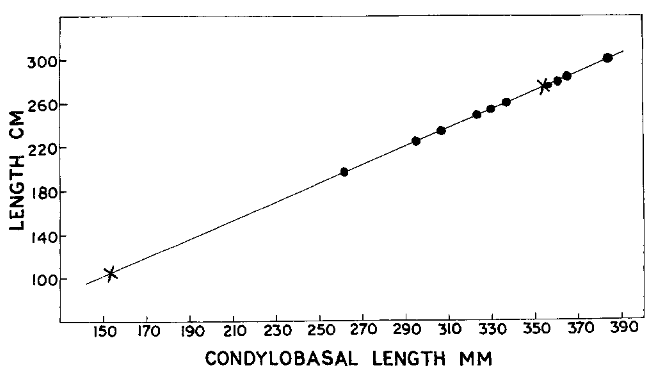

Fig. 5. *Dugong dugon.* Relationship between condylobasal length of skull and body length. x: Points drawn from exact measurements of both parameters

Table 2. *Dugong dugon*. Differences in skeletal features between adult male and juvenile female

Character	Description	
	Adult male	Juvenile female
Skull		
Neurocranium	Heavy, elongate	Light, round
Suture between frontals	Not clear	Clear
Suture between parietals	Not clear	Visible as wavy line
Articulation of exoccipitals with supraoccipital	Direct	Through intervening cartilage
Occipital condyles	Relation with exoccipitals not evident	Relation with exoccipitals evident
Rostrum (deflected part of premaxillaries)	Uniformly thick	Broad at both ends, narrow in middle. Beak-like, with lateral concavities in front half
Articulation between basisphenoid and exoccipitals	Masked by occipital condyles	Joint is distinct
Suture between basisphenoid and vomer	Indistinct	Distinct
Posterior end of jugal where it articulates with squamosal	Rod-like, extending below anterior end of squamosal	Truncate, juxtaposed to anterior end of squamosal
Number of sockets for incisors in premaxillary (1 side)	One	Two
Lacrymals	Distinct, well developed	Small, not elevated to same level as jugal and frontal, hence located in a depression
Vertebral Column		
Neural arches of first 2 vertebrae	Complete	Incomplete
Lateral foramina in 3rd to 5th cervical vertebrae (costotransverse foramina)	Present	Absent
Total number of vertebrae	57	53 (possibly a few lost)
Posteriormost vertebrae	Depressed	Compressed anteroposteriorly
Nature of centra of vertebrae	Hard and non-porous	Soft and porous
Projections on posterior margins of ribs	Conspicuous	Inconspicuous
Articular facets for ribs	Distinct	Indistinct
Posteriormost vertebra with closed neural arch	47th	40th
Fore limb		
Ankylosis of radius and ulna at their extremities	Complete	Incomplete
Ossification of carpals	Complete	Incomplete
Sternum		
Structure	Consists of single piece	Consists of 2 pieces, pre- and xiphisternum connected by cartilage

analysed for Specimens 1 to 14 (Table 1): (1) Palatal length; (2) muzzle width; (3) interorbital width; (4) postorbital constriction; (5) zygomatic width; (6) condyle width; (7) exoccipital width; (8) premaxillary length. These measurements were selected for analysis since they can easily be determined accurately, and can thus be employed by workers elsewhere.

To determine the differences, if any, between males and females for the characters selected, scatter diagrams for these characters were plotted, which revealed that a linear relationship exists between the condylobasal length and each of the 8 characters. The regression equation in each case was calculated by the method of least squares, assuming the line of best fit, $Y = a + b X$, where X denotes the condylobasal length, Y one of the skull measurements and a and b are constants. The analysis-of-covariance technique was employed for all characters to test for the significance of regression coefficients between sexes. The results indicate that, between sexes, all the characters studied were non-significant at the 5% probability level. Therefore, the data for males and females were pooled and the corresponding regression equations obtained. They are characteristic of the

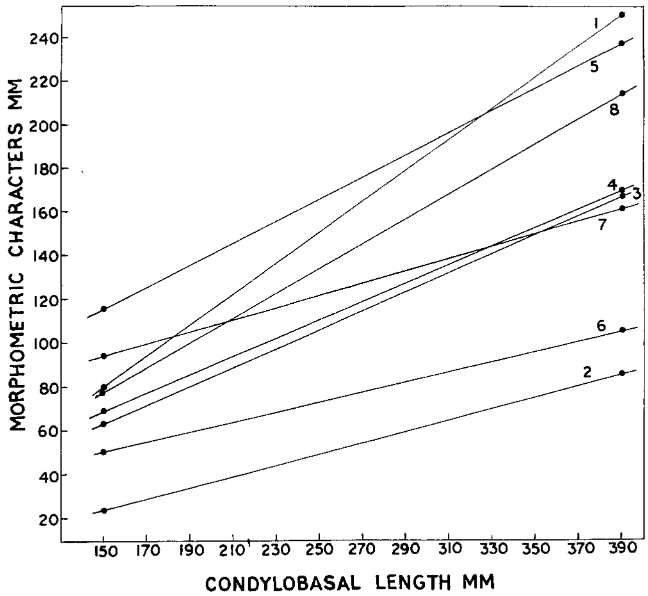

Fig. 6. *Dugong dugon*. Regression lines fitted to morphometric data on 8 skull measurements (see Table 3), sexes combined

Table 3. *Dugong dugon*. Regression equations of different skull measurements on condylobasal length

Sex	No. of specimens	Independent variable	Dependent variable	Regression equation: Before pooling sexes	After pooling sexes
Male	7	CBL	PL	PL = 0.677 CBL − 8.6	PL = 0.713 CBL − 26.5
Female	7	CBL	PL	PL = 0.653 CBL − 14.1	
Male	7	CBL	MW	MW = 0.152 CBL + 24.8	MW = 0.258 CBL − 14.5
Female	7	CBL	MW	MW = 0.241 CBL − 11.7	
Male	7	CBL	IOW	IOW = 0.605 CBL − 55.7	IOW = 0.435 CBL − 2.1
Female	7	CBL	IOW	IOW = 0.404 CBL + 9.8	
Male	7	CBL	POC	POC = 0.482 CBL − 12.7	POC = 0.421 CBL + 6.6
Female	7	CBL	POC	POC = 0.389 CBL − 13.3	
Male	7	CBL	ZW	ZW = 0.375 CBL + 87.6	ZW = 0.505 CBL + 40.3
Female	7	CBL	ZW	ZW = 0.493 CBL + 42.0	
Male	7	CBL	CW	CW = 0.097 CBL + 63.3	CW = 0.231 CBL + 16.4
Female	3	CBL	CW	CW = 0.242 CBL + 13.2	
Male	7	CBL	EXOW	EXOW = 0.015 CBL + 147.0	EXOW = 0.280 CBL + 52.4
Female	6	CBL	EXOW	EXOW = 0.278 CBL + 50.7	
Male	7	CBL	PMXL	PMXL = 0.333 CBL + 77.6	PMXL = 0.568 CBL − 6.9
Female	7	CBL	PMXL	PMXL = 0.559 CBL − 6.6	

CBL: Condylobasal length; PL: palatal length; MW: muzzle width; IOW: inter-orbital width; POC: postorbital constriction; ZW: zygomatic width; CW: condyle width; EXOW: exoccipital width; PMXL: premaxillary length dugong from the Indian region (Table 3); regression lines are shown in Fig. 6. Similar studies on metrical and non-metrical variation in the skulls of Gir lions have been presented by Todd (1965).

Discussion

Gohar (1957), on the basis of certain morphological and anatomical characters, mentioned below, considered the Red Sea dugong as forming a distinct subspecies called *Dugong dugong tabernaculi*. Bertram and Bertram (1966), after extensive investigations in Australia and adjacent areas with a view to collecting first-hand knowledge on the present taxonomic status of the dugong, opined that it may be divisible into an eastern and into a western species or variety.

According to Gohar (1957), the Red Sea dugong differs from the Indo-Australian dugong in maximum size attained, size at birth, relative development of mammae in the sexes, development of teeth, certain osteological characters, and other anatomical features. Since a detailed osteological study of the dugong from the Indian region has now been made, it is possible to compare its characteristics with those of the Red Sea dugong (Table 4).

From Table 4, it may be seen that the Red Sea dugong resembles that from India in most ways. However, some differences are apparent in Characters 1, 2, 9, and 10 which may be related to size (age) of the specimens examined. For example, in the specimens from India, the adult and juvenile display some interesting differences in certain skeletal features (ankylosis of radius and ulna, structure of sternum etc., Table 2) between each other which are due to difference in the age of the individuals. It may also be mentioned that the 3 skulls from specimens presumably from the Arabian Sea examined in this study also showed no differences from those from the Gulf of Mannar and Palk Bay.

In addition to the above similarities, the maximum size attained (so far only adults under 300 cm observed) and the size at birth (one 106 cm young specimen had well developed molars and was feeding independently as evidenced by the presence of gut contents) of the dugong from the Indian region compare very well with those reported for the Red Sea dugong (adult not exceeding 315 cm and young less than 100 cm at birth). Further anatomical comparison of the dugongs of the two regions could lead to the conclusion that the Red Sea dugong and the dugong from the Indian region belong to the same species, being separated only geographically. Those differences which are apparent do not seem to be so great as to justify their classification as distinct subspecies. Although Petit (1955) felt that a species which is widely distributed should constitute sub-species or geographic races, he commented that, among the dugongs, individual variations are so great and the number of specimens examined in each country so sparse that it is not possible to define the

Table 4. *Dugong dugon*. Comparison of osteological characters of Red Sea dugong with those of dugong from India

Character		Red Sea dugong	Indian dugong
1	Skull	Strong, heavy and broad	Strong, heavy and narrow
2	Roof of cranium	Distinctly convex	Slightly convex
3	Zygomatic arch	Strong	Strong
4	Premaxillaries	Broad and stout	Broad and stout
5	Angle of deflection of premaxillaries	Less prominent (actual angle not given)	Varies from 120° to 136°
6	Abortive teeth in lower jaw	Rare, only one case reported	Rare, actually seen in one case so far
7	Deciduous incisor tusk	Never attains a large size, does not co-exist with permanent tusk	Does not co-exist with permanent tusk
8	Number of sockets in symphysial part	Almost 1/3 of specimens have 4 on one side, 5 on other side	1 out of 7 examined, had 4 on one side, 5 on other side
9	Pelvic bones	Weak and slender	Strong
10	Radius and ulna	Free, fusion restricted to thick cartilaginous pad on surface, articulating with humerus	Fused together at heads

subspecies and their distribution area. According to Petit, the dugong form from the Red Sea is synonymous with the Indian form, and the differences between the Red Sea dugong and the Australian dugong may be greater than those between the Red Sea and Indian dugongs.

Therefore, before any definition of the subspecies of the dugong can be attempted, comparable data must be available on the various morphological, anatomical, and biological aspects from representative localities within the vast distribution area of the species: east from the Solomon Islands, west to the Gulfs of Suez and Aquaba (Bertram and Bertram, 1966). It is hoped that the information presented in this paper will be of use in such comparisons.

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