A new Miocene sirenian from Kutch, India

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Thewissen, J.G.M. and Bajpai, S. 2009. A new Miocene sirenian from Kutch, India. *Acta Palaeontologica Polonica* 54 (1): 7–13.

We report a new Miocene sirenian from District Kutch, State of Gujarat, India: *Domingia sodhae* gen. et sp. nov. The new species is a dugongine dugongid with flattened tusk-like upper incisors. Like some other Miocene dugongids, *Domningia* is large and has complex, bilophodont molars and three-rooted premolars, which are strongly worn. The rostrum is downturned significantly, similar to modern dugongs, and indicative of a specialized feeding mode. Phylogenetically, it is closely related to *Dioplotherium*, *Rytiodus*, *Corystosiren*, and *Bharatisiren*. Among these, *Domningia* is most similar to *Bharatisiren indica* and *Dioplotherium manigaulti*, in that all three taxa retain multi-rooted premolars. Similar to *Bharatisiren*, the nasal process of the premaxilla is long. *Bharatisiren* and *Domningia* are part of a late Oligocene and early Miocene radiation of dugongines in South Asia.

Key words: Mammalia, Sirenia, Miocene, India.

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Introduction

Miocene sirenians are known from most tropical regions of the world, and particularly common among these are dugongids which are larger than modern sirenians (Domning 1996). Miocene sirenians have been reported from India by Sahni and Mishra (1975), who named *Indosiren koenigswaldi* from the District Kutch (also called Kachchh or Cutch), in the Western Indian State of Gujarat and by Bajpai and Domning (1997), who named *Bharatisiren kachchhensis*, also from Kutch. Savage and Tewari (1977), Tewari et al. (1977), and Bajpai et al. (1987) discussed more Kutchi sirenians, and most recently Bajpai et al. (2006) described several species of Eocene and Oligo-Miocene sirenians from three formations of Kutch: the early Lutetian Panandhro Formation (formerly included in the Naredi Formation), the late Lutetian Harudi Formation (e.g., Bajpai et al. 1998; Bajpai and Thewissen 1998; Thewissen and Bajpai 2001) and the Chattian Maniyara Fort Formation (Satsangi and Trivedy 1978; Biswas 1992; Mukhopadhyay and Shome 1996; Raju and Ramesh 1998). Here, we report a sirenian from the Aquitanian (lower Miocene) Khari Nadi Formation, which overlies the Maniyara Fort Formation in Kutch.

Institutional abbreviations.—IITR-SB, Vertebrate Palaeontology Laboratory, Department of Earth Sciences, Indian Institute of Technology, Roorkee, Uttarakhand, India (curated by Sunil Bajpai). The IITR-SB acronym replaces the RUSB acronym previously used for this collection. This change reflects the elevated status of the institution previously known as University of Roorkee; it now is an Indian Institute of Technology (IIT). All curatorial information and the repository for this collection remain the same. In India, acronyms of fossils usually refer to the person who collected or described the specimen, and they sometimes do not reflect the repository of the fossil.

Systematic paleontology

Class Mammalia Linnaeus, 1758
Order Sirenia Illiger, 1811
Family Dugongidae Gray, 1821
Subfamily Dugonginae (Gray, 1821)
Genus *Domningia* nov.

Type species: *Domningia sodhae* sp. nov.

Etymology: Named for Dr. Daryl Domning, who has contributed greatly to the understanding of sirenian evolution.

Included species.—Type species only.

Diagnosis.—Dugongine with upper incisors which are greatly flattened medio-laterally, and multi-rooted upper premolars, unlike most dugongines. *Domningia* differs from *Corystosiren* and *Rytiodus* in having incisors that are more or less flat (not oval) on cross-section and in having a long nasal process of the premaxilla. In *Domningia*, the exoccipitals meet in the median plane dorsal to the foramen magnum, unlike *Dioplotherium* and *Bharatisiren*.

Stratigraphic and geographic range.—Aquitanian (lower Miocene) of Kutch, India.

Discussion.—Dugongines were defined by Domning (1994) on the basis of three unique characters. The most important

ones of these that can be discerned in *Domningia* concerns the shape of the postorbital process (character 43 of Domning 1994). The non-circular cross-section of the upper incisor further identifies the new genus as closely related to a cluster of genera similar to *Rytiodus*, previously referred to as the subfamily rytiodontines (this grouping is denied official status by Domning, 1994, but the name is still sometimes used informally). Genera with greatly medio-laterally compressed incisors include *Corystosiren*, *Rytiodus*, and *Dioplotherium*. *Domningia* differs from *Corystosiren* and *Rytiodus* in having more-or-less flat (not oval) upper incisors (character 141 of Doming 1994) and in having a long nasal process of the premaxilla (character 7). In both these features *Domningia* is more plesiomorphic than *Rytiodus* and *Corystosiren*, resembling the more basal *Dioplotherium*. *Domningia* differs from *Dioplotherium* in having the exoccipitals meet in the median plane dorsal to the foramen magnum (character 66 of Domning 1994).

Bharatisiren is a dugongine (Bajpai and Domning 1997; Bajpai et al. 2006) similar in many respects to *Domningia*. Both have multi-rooted premolars, for instance, a feature also found in *Dioplotherium manigaulti.* It is possible that these are deciduous premolars, as is the case in many post-Eocene sirenians. Both *Bharatisiren* and *Domningia* have a long nasal process of the premaxilla. We conclude that *Domningia* is a basal dugongine and part of a group of clades mainly charactized by their flattened upper incisors.

Domningia sodhae sp. nov.

Figs. 1–3.

Etymology: In honor to Mohan Singh Sodha from Kutch, India, who collected the holotype specimen.

Holotype: IITR-SB 3091, well-preserved, complete adult skull with left and right dentaries (Figs. 1, 3). The type specimen is in the collections of the "Fossil Park" in the village Vithon, Taluka Nakhatrana, District Kutch, State of Gujarat, India. The "Fossil Park" is a small, private museum run by Mohan Singh Sodha, who collected the specimen. As this museum does not keep a catalogue, the specimen has been entered in the catalogue of the Vertebrate Palaeontology Laboratory, Indian Institute of Technology, Roorkee, and casts of the specimen have been deposited with the institutions of the authors. Vertebrae were associated with the holotype, but only some of these can be positively identified among the large amount of uncatalogued sirenian material in this collection.

Type locality: Nangia, Kutch. The type specimen was found in a (dry) tributary of the Nithi River. This tributary crosses the road between the villages of Nangia and Sujapur 500 meters NW of Nangia, and the specimen was found near this intersection. The specimen is from a yellow sandstone near the top of the exposed section. The sandstone overlies a sandstone rich in *Turritella* and oysters. Co-ordinates of the locality are 23°22.337'N, 68°54.866'E.

Type horizon: The beds are part of the Khari Nadi Formation, and is generally presumed to be Aquitanian (lower Miocene) in age (Biswas 1992).

Material.—Additional material of this species is present in the collection of the "Fossil Park", but locality information is lacking for much of it. A fragmentary skull with some vertebrae and ribs (IITR-SB 3092) of another specimen was recovered by the authors at this locality in 2005. It is here tentatively referred to *Domningia*, in addition to another braincase from the Fossil Park (IITR-SB 3099).

Table 1. Dimensions (in mm) of the holotype of *Domningia sodhae* (IITR-SB 3091), Khari Nadi Formation Aquitanian (lower Miocene), Nangia, District Kutch, India.

Condylobasal length	510
Maximum height of jugal inferior to orbit	65
Zygomatic breadth	248
Distance between superior and inferior occipital condyle	42
Breadth across occipital condyles	102
Breadth of braincase at posterior frontoparietal suture	80
Greatest width of foramen magnum	50
Length of external nasal opening	190
Maximum width of external nasal opening	76
Length of orbit	96
Length of upper molar row	80
Maximum width between labial edges of upper cheek teeth	94

Diagnosis.—As for the genus, by monotypy.

Description.—The holotype skull (measurements are summarized in Table 1) is nearly complete and undeformed, with only the rostral part of the premaxillae slightly damaged, and the right zygomatic arch missing. Incisors are broken off, and the only tooth crowns preserved are the molars. The left zygomatic arch is preserved completely in place. Left and right tympanics are preserved. The orbits, temporal fossae, and tympanic regions have been left unprepared and are filled with sediment in order to protect the delicate areas underlying the sediment from storage and handling.

The premaxillae are large and ventrally deflected, housing the roots for the large tusks. These tusks are flattened mesiodistally, and are described with the other tooth crowns. The tusks are the only teeth in the premaxilla. Rostrally, the palatal side of the premaxillae bears fused palatine fissures that extend as a long and narrow slit in the median plane. Caudal to this opening are bilateral grooves on the palate located lateral to the median plane. The median suture of the palatines is raised in a crest. On the palate, the suture between premaxilla and maxilla is unclear. The part of the palate caudal to the incisors is broad, whereas the palate rostral to the cheekteeth is narrow (Fig. 1D). The lateral edge of the palate is sharp immediately behind the incisors, but flattens out into an irregularly shaped plane which extends onto the maxilla. The suture between left and right premaxillae makes up approximately 30% of the length of the skull.

The suture between premaxilla and maxilla is clear on the side of the face (Fig. 1D), extending dorsal and caudal from a point approximately halfway between the tip of the rostrum and the zygomatic arch. The suture can also be traced on the dorsal side of the skull, where the premaxilla contacts the dorsal side of the lacrimal, and then extends caudomedially, reaching the nasal opening at its posterior third (Fig. 1F). The rostral point of the nasal opening extends approximately to

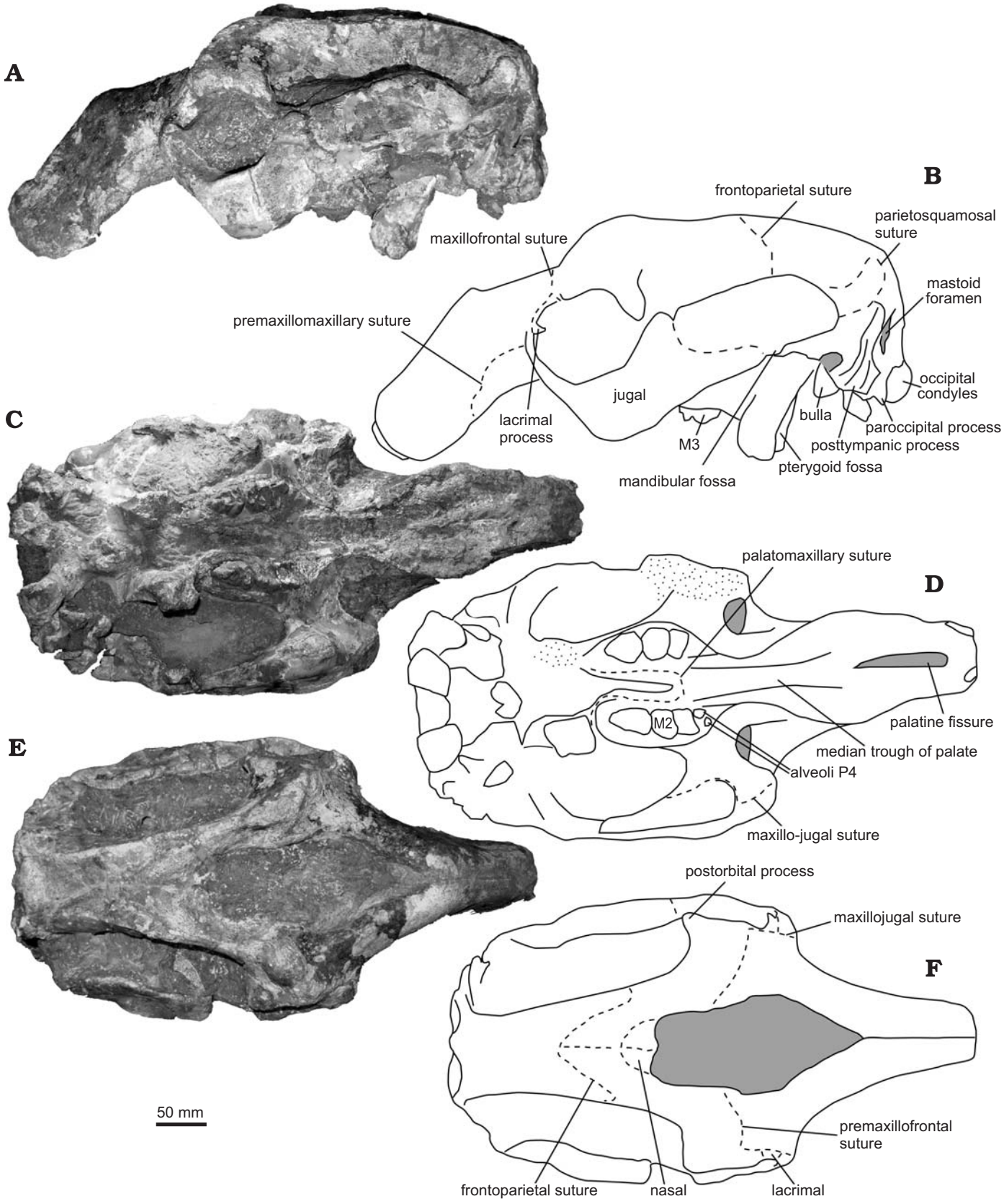

Fig. 1. Holotype (IITR-SB 3091) of the sirenian *Domningia sodhae* gen. et sp. nov., Khari Nadi Formation, Aquitanian (lower Miocene), Nangia, District Kutch, India, in lateral (**A**, **B**) and ventral (**C**–**F**) views. Photographs (A, C, E) and explanatory drawings (B, D, F).

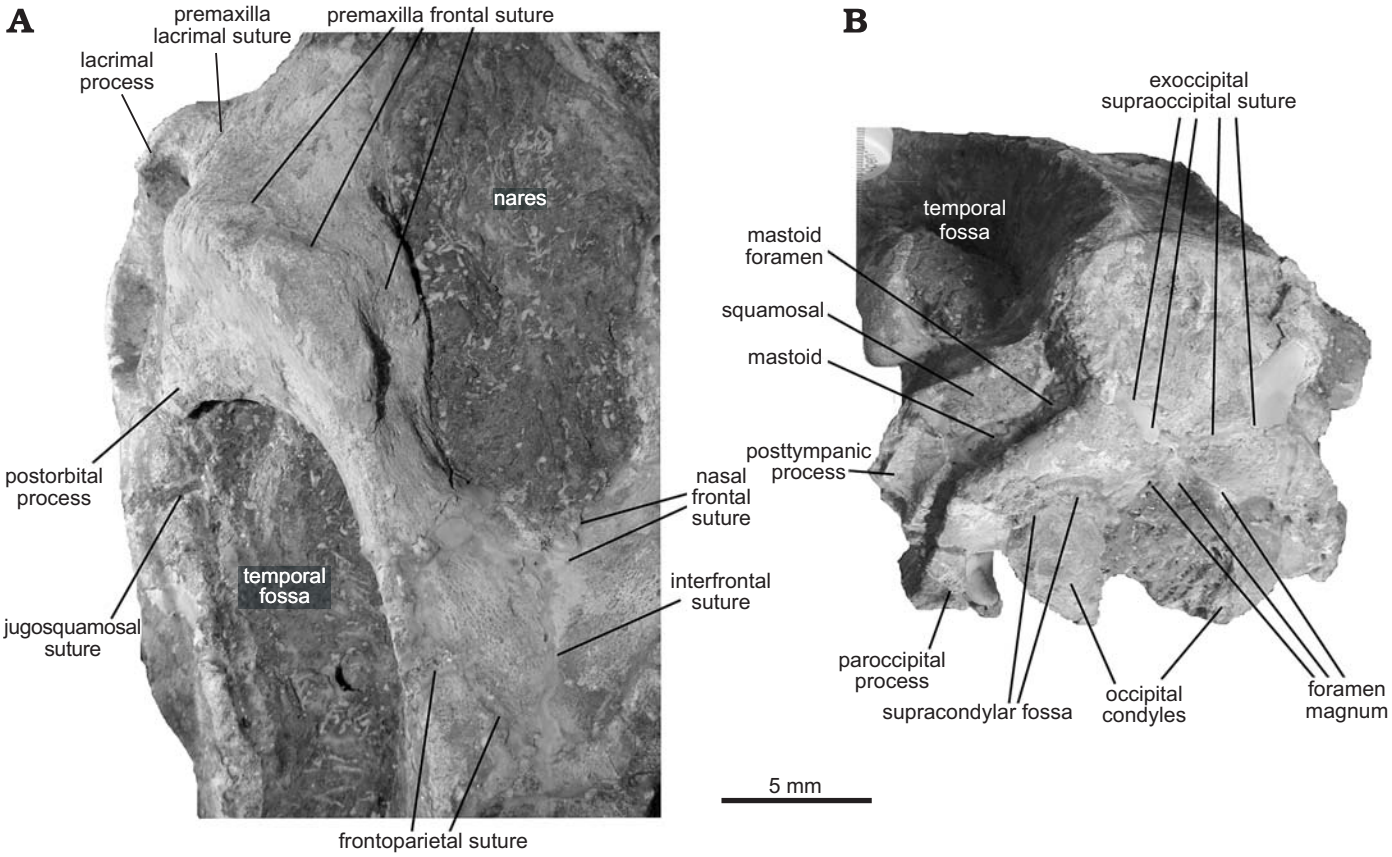

Fig. 2. Nasal opening and superior left orbit (**A**) and oblique occipital view (**B**) of the sirenian *Domningia sodhae* gen. et sp. nov. (IITR-SB 3091), Khari Nadi Formation, Aquitanian (lower Miocene), Nangia, District Kutch, India.

the level of the rostral part of the suture between premaxilla and maxilla.

The maxilla is the largest contributor to the palate in the molar region. The grooves on the rostral palate fuse caudally and form a sharply delineated, broad median trough (Fig. 1D). The palate narrows caudally and its edge is sharp. Caudally, this edge separates into two crests which extend on lingual and buccal sides of the teeth. There are no teeth in the rostral part of the maxilla. A triangular flat region, bounded by the two low crests occurs rostral to the upper molars, and held premolars earlier in life. One lingual and one labial alveolus for a premolar occur rostral to the first molar. The area rostral to these premolar alveoli is rugose and lacks alveoli. It is possible that an additional premolar was lost during life and the alveoli resorbed. The palatine contribution to the palate extends from the rostral area to the anterior edge of M1 and caudally to the middle of M3, and the bony palate bears a median groove between the molars.

The maxilla surrounds the oval infraorbital foramen, which is 30 mm in diameter mediolaterally, its greatest dimension. Lateral to the infraorbital foramen is the projecting rostral rim of the orbit. The zygomatic-orbital bridge of the maxilla is broad and forms the floor of the infraorbital canal, jutting out laterally behind the rostrum. This bridge is nearly level with the palate. The maxilla has a long suture with the jugal (Fig. 1B), and this suture extends rostral to the orbit. The lacrimal is a small, triangular bone articulating ventrally with the jugal and dorsally with the premaxilla (Fig. 1F). There is a long and stout lacrimal process, which projects into the orbit (Fig. 2A).

The frontal forms the supraorbital process. This process is large, triangular and projects lateroventrally, reaching within a centimeter of the jugal arch. Directly dorsal to the process, the frontal bears a strong crest-like tubercle, which extends from laterorostral to mediocaudal. Posteriorly this tubercle continues as the temporal crest (Fig. 2F). The frontal slopes rostrally between these crests toward the nasal opening. The premaxilla-frontal suture is on the rostral face of this tubercle (Fig. 2F). This suture extends vertically in front of the orbit and caudomedially on the forehead. No sutures are visible near the caudal edge of the nasal opening, but two symmetrical cracks suggest that the nasals are present and triangular, sharing a median suture and indenting the frontals in the midline (Fig. 2A). This part of the caudal part of the nasal opening is convex and projects into the nasal opening. The fronto-parietal suture is clear (Fig. 1F). On the dorsal surface of the skull, this suture extends from the temporal crest mediocaudally. The fronto-parietal suture reaches the temporal ridge well caudal to the caudal edge of the nasal opening. The dorsal side of the frontal is more or

less flat. The frontal surrounds the caudal one-third of the nasal opening. In the median plane, left and right frontal (or fused nasals) share a symphyseal suture. Lateral to the temporal crests, the fronto-parietal suture changes direction and extends caudally in the temporal fossa on the lateral side of the skull (Fig. 1F).

The parietal forms most of the dorsal wall of the braincase. The temporal crest of the frontal continues on the parietal and increases in height caudally, making the bone concave near the nuchal crest. The parieto-squamosal suture (Fig. 1B) extends on the lateral side of the braincase in a broad arch, and the parietal forms most of the wall of the braincase.

The jugal (zygomatic) contacts the lacrimal, and forms most of the rostral and ventral rim of the orbit (Fig. 1B). The most ventral part of the jugal is situated directly ventral to the lowest point of the orbit. The jugal forms the entire height of the zygomatic arch where it makes up the rim of the orbit, and forms a dorsal projection behind the eye, which nearly contacts the supraorbital process. Caudal to this process, the squamosal is the main contributor to the zygomatic arch, and the jugal is reduced to a narrow process. The jugal projects beyond the orbit both ventrally and caudally.

The orbit and temporal fossa are filled with sediment and cannot be studied. The pterygoid process is oval in cross-section and has a rugose tip. On the caudal side of the pterygoid process are two crests that converge proximally, and form a narrow and sharp crest dorsally, at the root of the process. The area between these crests is the weak pterygoid fossa.

The squamosal projects between parietal and supraoccipital on the lateral side of the skull. Ventral to the suture between squamosal and supraoccipital is a large mastoid foramen (Figs. 1B, 2B), basically an ossification defect between squamosal and supraoccipital. This defect extends ventrally between exoccipital and squamosal. A small part of the mastoid is exposed in the ventral half of this defect. Ventral to this part of the mastoid, the squamosal forms the posttympanic process (Fig. 2B). It is blunt and its lateral side bears a longitudinal groove. This process borders the caudal side of the external auditory meatus. The external auditory meatus is broad, approximately equally wide as long. Dorsal to the external auditory meatus, the squamosal bears a sigmoid ridge. Rostral to the external auditory meatus is the root of the zygomatic arch and the depressed mandibular fossa. The zygomatic process of the squamosal is broad and more or less horizontal. The caudal part of the zygomatic arch reaches far posterior on the skull, and is 21 mm from the paroccipital process.

The supraoccipital forms the dorsal half of the occipital side of the skull. Its dorsal surface is rugose, and its dorsal suture (the nuchal crest) is more or less straight. The occipital side of the skull is narrower centrally than dorsally and ventrally. The ventral suture of the supraoccipital extends from laterodorsal to medioventral, shaping the bilateral suture between supraoccipital and exoccipitals as a wide-open V (Fig. 2B). Laterally, the exoccipital extends in a ventral direction between occipital condyle and squamosal, and ends in a sharp but low paroccipital process which curves medially. There is a large supracondylar fossa extending along the dorsal and lateral sides of the occipital condyle. Left and right exoccipitals touch in the median plane dorsal to the foramen magnum. The occipital condyles are large and do not touch in the median plane. The basioccipital is narrow. A blunt bilateral process occurs on the anterior part of the basioccipital. The middle ear is deeply recessed and much of the ear region

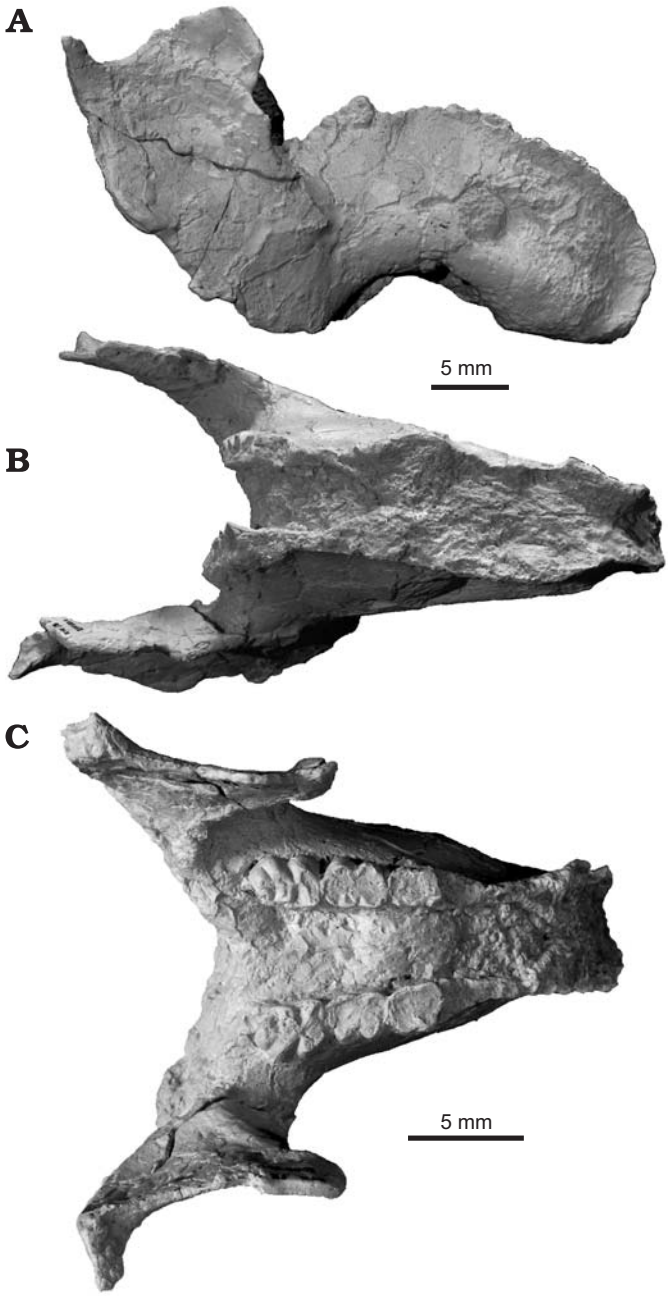

Fig. 3. Right lateral (**A**), oblique anterior (**B**), and occlusal (**C**) view of mandible of the sirenian *Domningia sodhae* gen. et sp. nov. (IITR-SB 3091, holotype), Khari Nadi Formation Aquitanian (lower Miocene), Nangia, District Kutch, India.

is covered with sediment. The tympanic is horseshoe-shaped and thick.

Among the upper teeth, crowns are only preserved for the molars. The first molar is strongly worn and the entire rostro-buccal side of the tooth is missing because of wear. The second molar is also worn, but still shows that the tooth had four main cusps with strong mesial and distal cingula. The M3 has a well-preserved crown that is lightly worn. It is bilophodont, with rostrally convex lophs and a strong mesial cingulum, but no other cingula. A cusp is present distal to the hypocone, and there is a basin buccal to this cusp. M1 is 21 mm long and 26 mm wide, M2 is 25 mm long and 28 mm wide, and M3 is 31 mm long and 24 mm wide. Only the root of the first incisor is preserved on left and right sides. This tooth is a tusk and is more-or-less oval in cross-section. Its maximum (mesio-distal) and minimum (labio-lingual) dimensions are 46 and 14 mm. Enamel is not visible on the part of the tusk that remains.

The lower jaw of the holotype has an evenly downturned, strongly concave lower margin, and a single, large mental foramen (Fig. 3A). The mandibular symphysis is firmly fused and the rostral tip of the mandible is narrow: it widens to form a rugose occlusal area which has three shallow bilateral depressions lined up from rostral to caudal. Three molar crowns are preserved on both sides. Rostral to these, there are three premolar alveoli. The rostral alveolus is narrow and long and the two caudal alveoli are broader and closely spaced. The two tooth rows are parallel (Fig. 3B). The caudal edge of the ascending ramus is damaged.

The ascending ramus originates buccal to m3 and covers the distal aspect of this tooth in lateral view. The rostral edge of this ramus is vertical and the area of insertion for the temporal muscle on the coronoid process reaches further dorsal than the mandibular condyle.

The m1 is strongly worn and all enamel is missing from its mesial side (Fig. 3C). The m2 is also worn, but the undulations in its enamel suggest that there were four cusps and a strong distal cingulid. The m3 preserves cusp morphology, it is bilophodont, and there are two cusps posterior to the hypolophid. The labial of these cusps is connected to the hypolophid. The dimensions of the lower molars are:

lower molar	length	width
m1	21 mm	15 mm
m2	25 mm	18 mm
m3	30 mm	20 mm

Discussion

Named Miocene sirenians from the Indian subcontinent include: *Indosiren koenigswaldi* Sahni and Mishra, 1975, and *Bharatisiren kachchhensis* Bajpai and Domning, 1997. The latter taxon is similar to late Oligocene *B. indica* Bajpai, Thewissen, Kapur, Tiwari, and Sahni, 2006, for which good cranial material is available. Moreover, because Oligocene and Miocene sediments of Kutch (Maniyara Fort Formation and Khari Nadi Formation, respectively) grade into each other, comparisons between *B. indica* and *Domningia* may be relevant, and these have been presented under the discussion of the genus. *Indosiren koenigswaldi* is known from two very incomplete and undiagnostic specimens (Sahni and Mishra 1975). The hypocone of the molars of *I. koenigswaldi* is not connected to the hypoloph, unlike *Domningia*.

Table 2. Scores of *Domningia sodhae* gen. et sp. nov. for the characters discussed by Domning (1994) and Bajpai and Domning (1997); char., character.

char.	score	char.	score	char.	score	char.	score	char.	score
3	1	6	1	7	0	8	1	9	1
11	0	13	1	14	0	16	?	31	?
32	?	36	?	37	?	38	?	42	1
43	1	51	1	66	0	67	2	70	0
73	1	74	0	75	?	76	1	77	?
82	1	84	?	85	2	87	?	88	?
89	0	91	?	97	2	99	0	101	?
102	1	103	?	115	?	121	1	122	3
123	1	125	?	126	1	127	?	128	1
129	1	136	?	137	?	138	0	139	0
140	?	141	2	142	?	143	1	144	2
146	?	150	0	151	0	155	1	156	0
157	0	158	0						

Savage and Tewari (1977) described *Metaxytherium* sp. (written, probably by mistake, as "*Halitherium* sp." in their figs. 1 and 2), also from Kutch, from deposits considered by them to be Burdigalian in age. Their diagrammatic drawing of the skull (Savage and Tewari 1977: fig. 1) shows a large process on the premaxilla anterior to the nasal opening, unlike *Domningia*, and more similar to *Bharatisiren*. In size, the specimen of Savage and Tewari (1977) is closer to *D. sodhae* than to the species of *Bharatisiren*.

Domning (1994) analyzed the systematic position of dugongines explicitly, and we have scored *Domningia* on the basis of the characters identified by Domning (1994; Table 2). The similarities between Miocene *Domningia sodhae* on one hand, and Miocene *Bharatisiren kachchhensis* and the late Oligocene *Bharatisiren indica* on the other are clear: all have multi-rooted premolars, a long nasal process of the premaxilla, and a deeply incised palate. The first and second of these characters are plesiomorphies for sirenians, but the palate character is a synapomorphy that excludes other dugongines. All three of these features are shared with a single species of non-Indian sirenians: *Dioplotherium manigaulti*. Based on these observations, we hold *Domningia*, *Bharatisiren*, and *D. manigaulti* to be a basal group within the dugongines, with flat incisor tusks. In South Asia, this group formed a distinctive faunal element in the late Oligocene and early Miocene.

Stratigraphic and geographic range.—Range of holotype only.

Acknowledgements

We thank Mohan S. Sodha (Fossil Park, Vithon, India) for allowing us to describe the specimen and Mahesh G. Thakkar (Bhuj, Kutch, India) for facilitating it. Amy Maas (Northeastern Ohio Universities College of Medicine, Rootstown, USA) prepared the specimen, and Daryl Domning (Howard University, School of Medicine, Washington, D.C., USA) provided comments on the manuscript and corrected some of our interpretations, any remaining mistakes are obviously ours. This work was supported by the Department of Science and Technology (DST), Government of India (Ramanna Fellowship grants), and partly also by grants from the DST and National Science Foundation (USA) under the Indo-US Scientific Cooperation Programme (Sanction No. DST/INT/US, NSF-RP099/2002 to SB) and NSF-EAR 0207370 and 0745543 and NSF-INT 0216710 to JGMT).

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