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Morphology and organ weight of dugongs (*Dugong dugon*) in Thai waters

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ABSTRACT
Data were obtained from dugong specimens collected in Thai waters during 22 June 1979 to 31 October 2009. Length and weight of calves ranged from 0.97-1.31 and 14-50 kg (n = 14). The average length of mature male and female was 2.58 ± 0.18 m (SD) (n = 12) and 2.55 ± 0.17 m (n = 23). The average weight of mature male and female was 249.6 ± 40.6 kg (n = 7) and 251.2 ± 55.2 kg (n = 17). Meat was the main part of dugong followed by blubber, while bone and internal organs were of similar proportion (n = 44). Organ weight from maximum to minimum was; lung, liver, kidney and heart. Weights (kg) of lung: liver: kidney: heart in male were 2.99 ± 1.01: 2.52 ± 0.73: 0.88 ± 0.21: 0.53 ± 0.18 (n = 11) and those weights (kg) in female were 3.35 ± 0.94: 3.09 ± 1.00: 1.26 ± 0.50: 0.53±0.19 (n = 7). Brain was very small, only 0.1% of body weight. Food contents in the stomachs of male and female were 1.92 ± 0.99% and 2.8 ± 1.13% of their body weight (n = 45). The maximum length of intestine was 12.04 ± 2.1 times of the body length (n = 44).

KEYWORDS: *Dugong dugon*, morphology, organ weight

INTRODUCTION

The body of the dugong is markedly robust anteriorly and narrows progressively rearward from the umbilicus to the point where it joins the base of the tail fluke (Marsh et al., 1978). Dorsally, the body is grey to brown in color but becomes somewhat lighter ventrally. The body of a calf is grey dorsally and pink ventrally. Marsh et al (1978) reported that older animals have large areas of unpigmented skin and are extensively scarred, particularly dorsally. Observation from necropsy of 60 carcasses, found most of the adult dugongs had unpigmented skin dorsally or white scars (Fig. 1). Normally these dugongs often dived deeper than other dugongs without white scars while they were travelling in the same group into seagrass bed and also dived longer than other dugongs. We noticed that the white scar dugongs took more time to breathe in comparison to other dugongs without white scar in the same group (Adulyanukosol, unpublished data). The mouth opens ventrally on the head and below the broad flat muzzle. The dugong is remarkable for the enormous development of its upper lip area which helps it grab seagrasses from the bottom during a dive (Marsh et al., 1978; Marshall et al., 2003). The eyes are small and not prominent. There are no ear pinnae (Fig. 2a). The external nares lie close together and are situated antero-dorsally. They are closed during diving by anteriorly hinged valves (Fig. 2b). Hairs are lightly scattered over the body surface but become denser and more robust on the muzzle and around the mouth. Both dugongs and manatees have bristle-like hairs covering the oral disk (Marshall et al., 2003; Fig. 2c, d). The flippers are short, approximately l5% of total adult body length (Spain and Heinsohn, 1975), rounded at the ends and, unlike those of the West Indian and West African manatees, lack nails (Jefferson et al., 1993). Dugongs appear to use their flippers little during rapid swimming. Flippers are usually held close to the sides of the body (Marsh et al., 1978). Callouses are present on the anterior ventral part of the flipper on all specimens observed (Marsh et al., 1978) except on the very small calf or presumable new born calf. This is likely to be caused by feeding behaviors. In my observation of captive dugongs, they used the flippers to crawl across the bottom of the tank and sometimes used to lift the seagrasses into their mouths. These callouses were dark green color. The large, triangular, horizontally-expanded tail fluke is the principal organ of locomotion and works vertically with slow, powerful beats (Marsh et al., 1978; Nishiwaki and Marsh, 1985).

Two pairs of upper incisors are present in the juvenile dugong. The first is small, does not erupt and is resorbed during the course of development. Then the sockets are lost in the expansion of those of the second upper incisors (Marsh et al., 1978; Fig. 3). The second incisors or tusks generally grow and erupt in the mature male. The second incisor teeth have persistent pulps and, apparently, continue to grow throughout the life of the animals. In the adult males, the erupted tusks become sharp through wear on their outer distal margins and may become weapons of offense and

defense (Marsh et al., 1978). The male dugong at Toba Aquarium, Japan uses his tusks in mounting and performing sexual behaviors (Marshall et al., 2003).

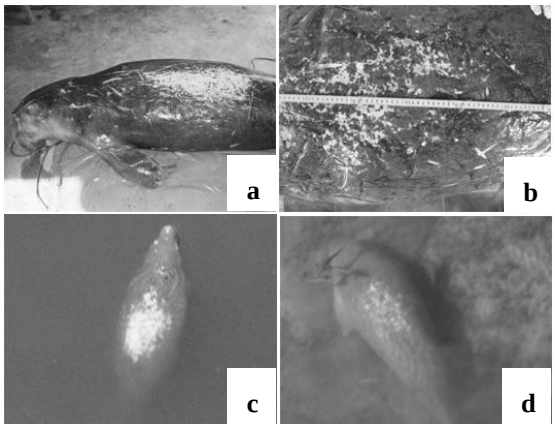

Fig. 1 Several older dugongs have large areas of unpigmented skin and are extensively scarred, particularly dorsally. (a) a specimen from Chumphon Province, (b) a dorsal side of the specimen from Trang Province, (c) a wild dugong at Talibong Island, Trang, and (d) a wild dugong at Muk Island, Trang.
(Photos (a, b) by K. Adulyanukosol, (c) by C. Prasitthiporkul and (d) by S. Thongsukdee)

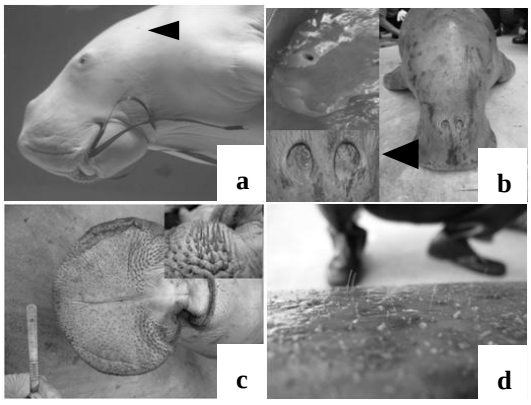

Fig. 2 (a) a muzzle includes mouth with a large upper lip, small eyes and tiny pinnae , (b) nares lie close together and are closed during diving by anteriorly hinged valves (in-set photos), (c) a large upper lip (oral disk) and in-set photo is a close up of the bristle-like hairs which cover the lip, and (d) hairs scattered over the body. (Photo (a) by C. Wutthivorawong, and photos (b-d) by P. Cherdsukjai)

It is difficult to distinguish between premolar and molar teeth in the dugong since in situ replacement of the milk dentition does not occur. During the life of the dugong there are a total of six pairs of cheek teeth in both jaws. The anterior teeth

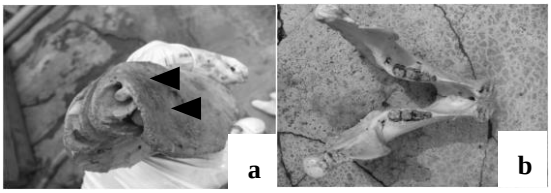

Fig. 3 (a) 2 pairs of upper incisors are present in the juvenile dugong. The first is small does not erupt (upper), and is resorbed during the course of development. The second (lower) become the tusks, and (b) 4 pairs of teeth at lower jaw of the same animal.

progressively fall out or are resorbed and the sockets become occluded with bone. Further teeth are added posteriorly during growth and the whole process continues until only two pairs of teeth remain in each jaw in the older animals. These appear to have persistent pulps and may continue to grow throughout life (Marsh et al., 1978; Nishiwaki and Marsh, 1985). Old animals have 2-3 pairs of teeth in each jaw (Marsh, 1980; Fig. 4a).

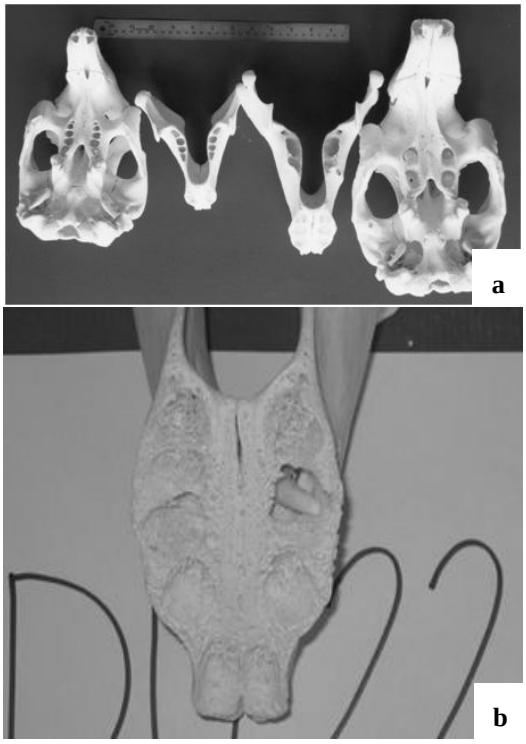

Fig. 4 (a) Two skull specimens show different numbers of teeth (teeth were taken out), and (b) A horny pad at lower jaw showing four pairs of rudimentary sockets occur under the lower horny pad. Vestigial incisor can be seen in the socket (Du-227, a male of 2.47 m long, rare case in Thai specimens). (Photo (a) by K. Adulyanukosol and photo (b) by P. Boukaew)

A horny pad covers the downturned symphysial

portion of the lower jaw and a corresponding pad is located on the ventral interior surface of the premaxilla (Marshall et al., 2003). Normally, four pairs of rudimentary sockets occur under the lower horny pad (Marsh et al., 1978). Some of these sockets may occasionally contain vestigial incisors. The vestigial incisors on the rudimentary sockets in Thai specimens were rare (Fig. 4b). Dugong has about 58-60 vertebrae. The formula of bone is Cervical-7: Thoracic-19: Lumbar-3: Sacral-1: Caudal-28 to 30. Most of Thai dugongs have 18 pairs of rib and few of them have 19 pairs of rib.

MATERIALS AND METHODS

Data were obtained from dugong specimens collected in Thai waters from 22 June 1979 to 31 October 2009. Before necropsy, specimens were identified by their sexes, measured body length and body weight. During necropsy, internal organ sizes were measured (width and length) and weight. Weight of body parts of dugongs were separated into 4 parts; meat, blubber, bone and internal organs. Four major internal organs (lung, liver, kidney and heart) were compared for their weight. Three external manifestations of sexual dimorphism are known as following.

1) The relative distance between the center of the anal and genital orifices. The anal and genital orifices are almost nearby in the female, while in the male they move relatively further apart during the course of development (Spain and Heinsohn, 1975). Basically the genital opening of male locates almost in the middle between umbilicus and anus (Fig. 5a, b). Nevertheless it is difficult to observe the umbilicus in old animals.

2) The presence of erupted tusks in the animals of mature size is usually taken to indicate a male dugong (Fig. 6a). This may not be always true since at least one fully mature female has been observed with erupted tusks (Spain et al., 1976). In Thai specimens all mature males have erupted tusks. Only 3 old female specimens have worn tusks, 2 in the Andaman Sea and 1 in the Gulf of Thailand (Fig. 6b). But there are very rare cases of erupted tusk females. The erupted parts of females were shorter than those of the males and were not as noticeable as found in the males.

3) The noticeable nipples in mature females. Mature females have well-developed axillary nipples. These are also noticeable in mature male animals but are much less developed (Marsh et al., 1978). In Thai dugongs the tiny nipples were noticed in young calves in both sexes. The nipples of mature females were about 2-5 cm in length. However I have never seen the well-developed nipples in mature males yet (Fig. 7 a-f).

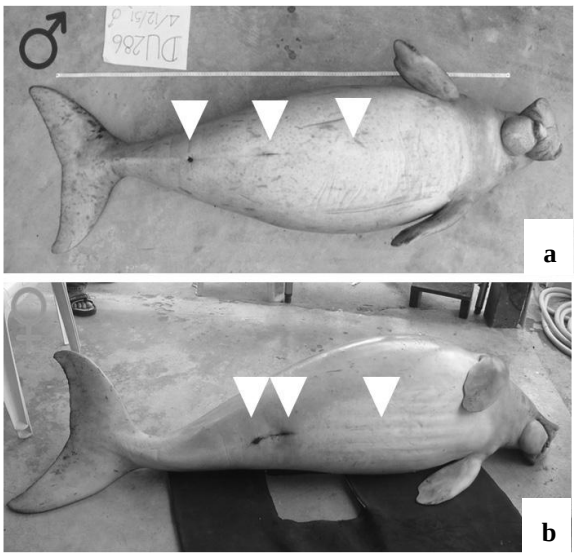

Fig. 5 The differences between male and female dugongs were noticeable by the distance between umbilicus to the genital opening. (a) in male; the genital opening locates almost in the middle between umbilicus and anus (picture from a male of 1.63 m long), and (b) in female; the genital opening is very close to anus (picture from a female of 1.74 m long) [1= umbilicus, 2= genital opening and 3= anus] (Photos by S. Manawattana)

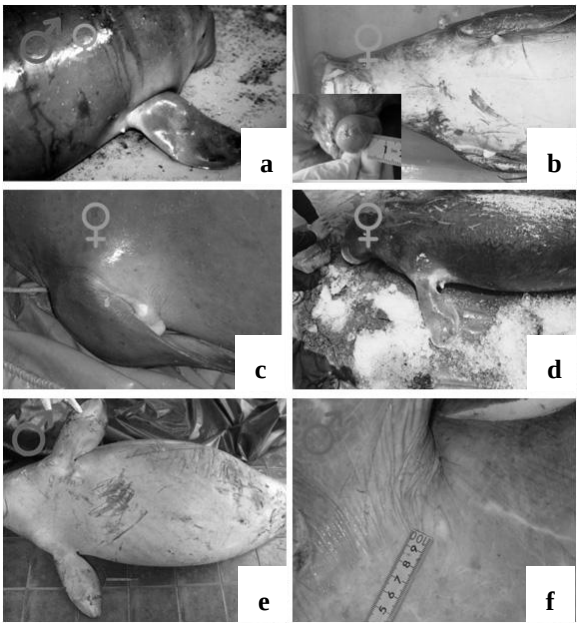

Fig. 6 The tusks of mature males usually protrude. (a) A pair of tusks can be easily seen in this specimen, taken when specimen was alive in Phang-nga Province, and (b) a head of a very old female of 2.81 m long from Trang Province (Du-299) before dissecting showing the erupted tusks.

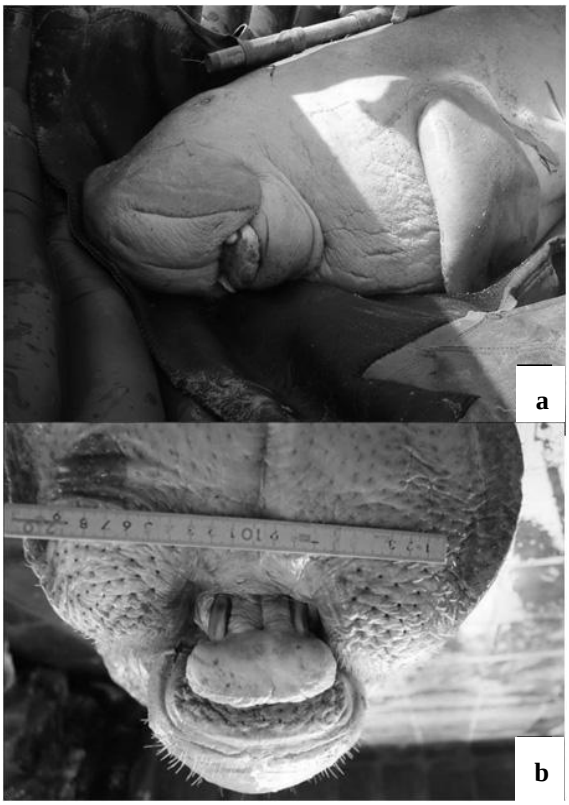

Fig. 7 General views of dugong nipples in different male and female. (a) Very young calf in both sexes has tiny nipples (photo of a male of 1.3 m long), (b, c, d) the prominent nipples of mature females, inset in (b) showing the close up of the nipple, and (e, f) unclear nipples of mature males. (Photos by P. Boonyanate, S. Manawattana and K. Adulyanukosol)

RESULTS AND DISCUSSION

Marsh (1980, 1995) estimated the mean birth length of Australian dugongs from the length of postnatal animals as 1.15 m. Nair et al. (1975) presumed that the birth length of Indian dugongs was less than 0.95 m. Asymptotic length estimates are almost the same; 2.74 m for Thai and 2.69 for Australian dugongs. Marsh et al. (1984) reported that dugongs of less than 2.2 m long were immature, whereas those longer than 2.5 m were probably mature.

Length-weight relationship

We have records of dugong stranding since 1979 to June 2009, the smallest calves were 0.97 m in length and 14 kg in weight. The known sex, length and weight calves were in total 14 animals which the length and weight ranged from 0.97-1.31 m in body length and weighed 14-50 kg. In this study, the mature dugongs were considered from; 1) the study of Adulyanukosol et al. (1998), and 2) the length and shape of the tusks including the number and shape of the available molar teeth according to Marsh (1980). The average length of mature male and female was 2.58 ± 0.18 m (SD) (n = 12) and 2.55 ± 0.17 m (n = 23), respectively. The average weight of mature male and female was 249.6 ± 40.6 kg (n = 7) and 251.2 ± 55.2 kg (n = 17), respectively. A male dugong of 2.75 m long had the maximum weight of 310 kg and the longest male was 2.94 m. A female dugong of 2.81 m long had the maximum weight of 335 kg and the longest female was 2.82 m (data until October 2009). All measurements were the straight length. However some people measured curve length. Adulyanukosol (2004) suggested that the curve length was about 10-15 cm greater than the straight length.

The growth curve was calculated from 65 dugongs which had both length and weight were measured. The length-weight relationship equation was; $y = 19.108 \times^{2.8103}$ and $R^2 = 0.945$ (y = body weight in kg and x = body length in m) (see Adulyanukosol et al., 2009).

Weight of four groups of body parts

In some countries dugongs have been hunted for meat and oil as an important traditional fishery i.e. the region of Torres Strait between Cape York and Papua New Guinea (Marsh et al., 2004). Dugongs are sources of protein food for human consumption. In addition hunting dugongs for food is still traditional for some groups of people i.e. aborigines in Australia (Marsh et al., 2002, 2004; Kwan, 2002). In the past, dugongs used to be hunted around Okinawa waters, Japan to pay tax [Ohama, 1971 cited from Shirakihara et al. (2007)]. Dugongs have extremely thick skin (Nishiwaki and Marsh, 1985). However this thickness would include blubber. The maximum dorsal thickness of Thai dugongs ranged from 2.05-4.4 cm(n= 12; 1.39-2.64 m in body length). The thick skin possibly helps to protect dugong from predators (shark bite) or injury during feeding at the bottom (shells or other sessile organisms). Dugongs have dense skeletons which support the bottom-feeders (Nishiwaki and Marsh, 1985). Dugong bones were denser and heavier than those of dolphins in the same size.

Complete measurement data sets of dugong body parts were obtained from 41 specimens (24 males and 17 females). Data of weights were separated into 4 groups; 1) skin and blubber, 2) meat, 3) bone, and 4) internal organ. The results of the weights of dugong body parts showed that the meat was the main part of dugong following by blubber, while bone and internal organs were of similar weight. Bone weight in male was a little higher than internal organ (19.84%/ 18.86%) in contrast with those of female (19.18%/ 19.46%). Female was likely to have more meat (35.32%) than male (33.18%) while male was

likely to have more blubber (28.12%) than female (26.04%).

Organ weight

Comparison of weights of major internal organs (liver, lung, heart and kidney) was made in order to be the basic information of organ weight of dugong. Generally while performing necropsy on the dugong carcasses, internal organs were measured as much as possible depending on the condition of carcasses (fresh or decomposed) and the limited time of studying when dissecting on site. To reduce the large variation, we compared the data of major internal organ weight only of the large dugongs with fresh to fairly fresh conditions of carcasses (body length > 2 m, n = 18). Organ weight from maximum to minimum was; lung, liver, kidney and heart. Liver weight in a few individuals was slightly higher than lung weight. Weights (kg) of lung: liver: kidney: heart in male were 2.99 ± 1.01: 2.52 ± 0.73: 0.88 ± 0.21: 0.53 ± 0.18 (SD) (n = 11), respectively and those weights (kg) in female were 3.35 ± 0.94: 3.09 ± 1.00: 1.26 ± 0.50: 0.53±0.19 (n = 7), respectively. Female tended to have lung, liver and kidney larger than those organs of the male.

Only one specimen had brain measurements but it had no record of heart weight. This dugong was a female of 2.38 m long and 220 kg in weight. The weight (kg) of brain: lung: liver: kidney was 0.22: 2.4: 5.6: 1.2. Size of the brain was 5x10 cm in right lobe and 4.5x9.8 cm in left lobe. The brain was very small when compared to body size, only 0.1% of body weight. These results can be used as standard organ weights to determine abnormal evidences in pathologic study.

Food remaining in the stomach

Domning and Beatty (2007) concluded that mature male dugong with (erupted tusks) did not consume more rhizomes than females (without erupted tusks). This would suggest that the amount of food consumption between male and female was the same. Seagrasses were mainly masticated by the horny plates (horny pads) which are located before the teeth. The horny plates were expected to have more function in this process than the teeth. Lanyon and Sanson (2006) also reported that the cheek teeth in dugongs are considered to be largely non-functional whereas the oral horny pads are important both in mechanical disruption of the diet and in conveying seagrasses through the mouth. The photographs of horny plates (horny pads) are in Fig. 9a-d.

In our study, food remaining in the stomachs was obtained from 45 specimens (25 males and 20 females). Body length and body weight of male and female were: 2.02 ± 0.39 m (SD) and 160.9 ± 75.03 kg; 2.15 ± 0.51 m and 187 ± 97.76 kg, respectively. Food contents in male stomach and female stomach were 2.95 ± 2.00 kg (or 1.92 ± 0.99% of their body weight) and 5.92 ± 4.7 kg (or 2.8 ± 1.13% of their body weight), respectively. Maximum food found in the stomach was 5.01% of the body weight (Data until 16 October 2009). The amount of stomach content of female specimens was slightly higher than that of the male with similar size.

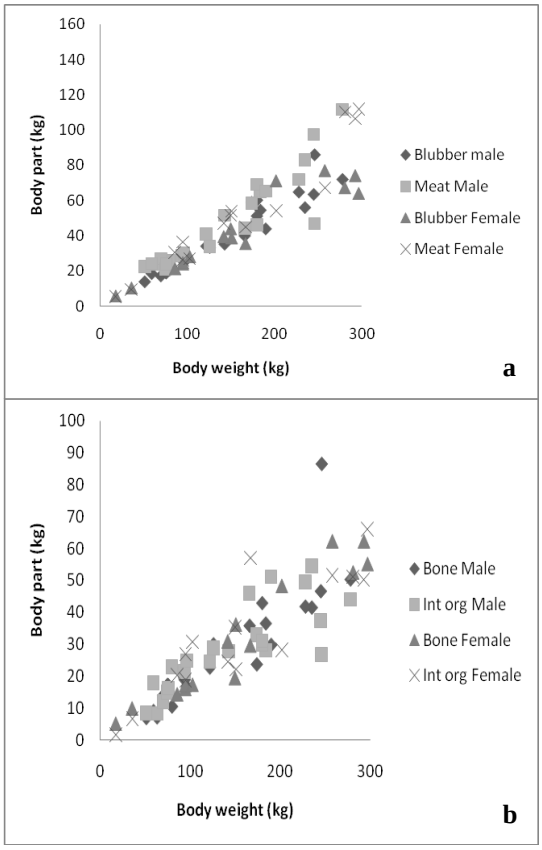

Fig. 8 The relationship between body weight (kg) and groups of body parts. (n= 42, 24 males and 18 females; data until 30 June 2009); (a) between blubber-meat and body weight, and (b) between bone-internal organs and body weight. Int org= internal organs.

Ratio of large intestine: small intestine

Marsh et al. (1977; 1978) stated that the large intestine of dugong increased with growth. In an adult dugong the large intestine is up to 25 m long, about twice as long as the small intestine. The large intestine grows with positive allometry in relation to body length. In contrast, the small intestine and caecum grow isometrically with regard to the same standard (Spain and Heinsohn, 1975). Reynolds and Rommel (1996) mentioned that the large long intestine of manatee including numerous ridges in the large intestine (mainly the colon) which run perpendicular to the direction of passage of food

could retard progress of the passage of the digesta. Length of the gastrointestinal tract (stomach and intestines) was very long, ≥ 40 m long or about 12-14 times of the body length. The photograph of gastrointestinal tract of dugong is shown in Fig. 10.

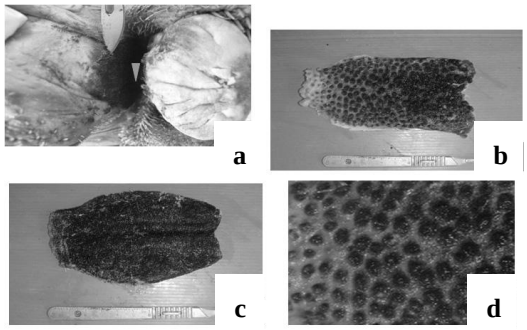

Fig. 9 Dugongs likely use the horny plate to masticate the seagrasses rather than molar teeth (a) location of horny plate in dugong mouth (arrow), right oval shape is horny palate, (b) an upper horny plate has large knobs, (c) a lower horny plate has fine knobs, and (d) expanded photograph of the upper horny plate which is composed of numerous hard knobs. Each knob has brush like organs. (Adapted from Adulyanukosol, 2009)

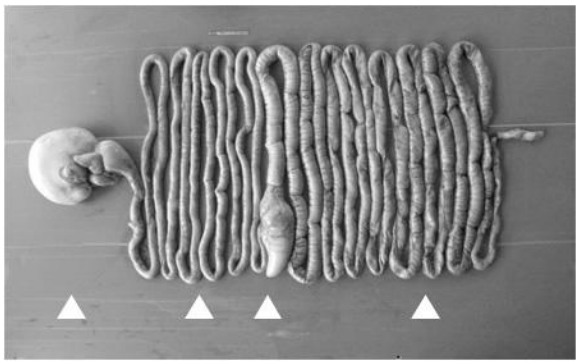

Fig. 10 Photograph showing the gastrointestinal tract of the dugong. Arrows from left to right are stomach, small intestine, ceacum and large intestine. (from Adulyanukosol, 2009)

We found that the maximum length of intestine (small and large intestines) of 44 dugongs (23 males and 21 females) ranged from 7.8-41.61 m long (average 24.66 ± 8.14 m (SD)) or 12.04 ± 2.1 times the body length. Maximum total length of small and large intestines is 17.08 times the body length. Dugong body length ranged from 1.0-2.81 m long (data until 16 October 2009). The ratio between the length of the intestine and body length of dugong in comparison to that of the manatee was not very much different (in manatee included the length of stomach). The length of both small and large intestines in male was likely longer than those in female with the same body size. The relationship between the length of small and large intestine with the body weight is shown in Fig. 11.

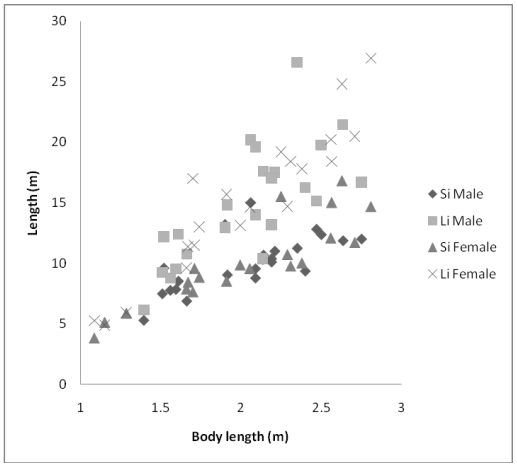

Fig. 11 The relationship between body length (m) and small and large intestines. (n= 44, 23 males and 21 females; data until 16 October 2009. Si= small intestine, Li= large intestine

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The efforts of collecting and carrying out necropsy of dugong carcasses of the staff of PMBC are highly appreciated. We would like to thank the staff of the Marine and Coastal Resource Research Center (Eastern Gulf) who assisted in data collecting in the eastern part of the Gulf of Thailand. Without the cooperation of local fishermen, Provincial Fishery Officers, Department of Fishery (DOF), Marine National Park, Wildlife and Plant Department, Department of Royal Forestry, and NGOs, data collecting would not be possible. Budget for collecting and accumulating data over 3 decades from Department of Fisheries (1979-2003) and DMCR (2004-present).

REFERENCES

Adulyanukosol, K. (in Thai, 2009). General information; Dugong of Thailand. In Marine and Natural Resources. Mangrove Management Center (Forth center). pp.1-20

Adulyanukosol., K. Prasittipornkul, C., Man-anansap, S., and Boukaew, P. (2009). Stranding records of dugong (*Dugong dugon*) in Thailand. Proceedings of the fourth Symposium of SEASTAR and Bio-logging Science, 15-17 December 2007, Phuket, Thailand. pp. 51-57

Adulyanukosol, K., Amano, M., and Miyazaki, N. (1998).. Preliminary study on age determination of dugong (*Dugong dugon*) in Thailand. *Proceedings of the Fourth International Scientific Symposium (IOC/WESTPAC)*

"Role of Ocean Sciences for Sustainable Development", 2-7 February 1998. Okinawa, Japan. pp. 369-377.

Domning, D.P., and Beatty, B.L. (2007).. Use of tusks for

feeding by Dugongid Sirenians: Observation and tests of hypotheses. *The Anatomical Record*. **290,** 523-538

Jefferson, T.A., Leatherwood, S., and Webber, M.A. (1993).. FAO Species Identification Guide. Marine Mammals of the World. Rome, FAO. pp. 204-207

Lanyon, J.M., and Sanson, G.D. (2006). Mechanical disruption of seagrass in the digestive tract of the dugong. *Journal of Zoology*. **270,** 277–289

Marsh, H. (1980). Age determination of the dugong (*Dugong dugon* Müller) in the northern Australia and its biology implications. *Reports of the International Whaling Commission, Special Issue.* **3,** 181-201

Marsh, H. **(**1995). The life history, pattern of breeding and population dynamics of the dugong. In: Population Biology of the Florida Manatee. (Eds T.J. O'Shea, B.B. Ackermann and H.F. Percival.) US Department of the Interior, National Biological Service, Information and Technology Report No. 1. pp. 75-83

Marsh, H., Heinsohn. G.E., and Spain, A.V. (1977).. The stomach and duodenal diverticula of dugong (*Dugong dugon*). In: Functional Anatomy of Marine Mammals. Vol.3 R.J. Harrison (ed.) Academic Press Inc (London) Ltd. London. pp. 271-295

Marsh, H., Spain A.V., and Heinsohn. G.E. (1978).. Physiology of the dugong. *Comp. Biochem.Physiol.* **6lA,** 159-168

Marshall, C.D., Maeda, H., Iwata, M., Furuta, M., Asano, S., Rosas, F., and Reep, R.L. (2003). Orofacial morphology and feeding behaviour of the dugong, Amazonian, West African and Antillean manatees (Mammalia: Sirenia): functional morphology of the muscular-vibrissal complex. *Journal of Zoology*. **259,** 245-260

Nair, R.V., Mohan, R.S.L., and Rao, K.S. (1975).. The dugong, *Dugong dugon*. ICAR Bulletin of the Central Marine Fisheries Research Institute. Vol 26. 45 pp

Nishiwaki, M., and Marsh. H. (1985). Dugong, Hand book of Marine Mammals Vol 3. Academic Press Inc (London) Ltd. pp. 1-131

Shirakihara, M., Yoshida, H., Yokochi, H., Ogawa, H., Hosokawa, T., Higashi, N., and Kasuya, T. (2007).. Current status and conservation needs of dugongs in southern Japan. *Marine Mammal Science.* **23(3),** 694-706

Reynolds, J., and Rommel, S.E. (1996). The structure and function of the gastrointestinal tract of the Florida manatee, *Trichechus manatus latirostris*. *Anatomical Records*. **245,** 539-558

Spain A.V., and Heinsohn, G.E. (1975).. Size and weight allometry in a north Queensland population of *Dugong dugon* (Müller) (Mammalia: Sirenia). *Aust. J. Zoo.* **23,** 159-168

Spain, A.V., Heihsohn, G.E., Marsh, H., and Correll, R.L. (1976).. Sexual dimorphism and other sources of variation in a sample of dugong skulls from North Queensland. *Aust. J. Zool*. **24,** 491-497