Stomach contents of dugongs (*Dugong dugon*) from Trang Province, Thailand

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ABSTRACT
Six stomachs of stranded dugongs, collected in Trang Province, Thailand during January 1997-January 1999, were inspected. Based on physio/morphological characters of leaves and epidermal cells, seagrass fragments were identified down to species under stereo - and compound-microscopes. Nine species of six genera of seagrasses were found in dugong stomachs, 4-6 species each and their biomass was determined in terms of dry weight. The percentage dry weight of each species found in the stomach contents was as follows: *Halodule* spp. 0.84-44.99%, *Halophila ovalis* 3.11-29.60%, *Thalassia hemprichii* 3.50-28.69%, *Cymodocea* spp. 5.06-42.52%, *Syringodium isoetifolium* 0.42-22.39%, and *Enhalus acoroides* 31.76-41.39%. The biomass of *Halophila decipiens* was not determined because of its scarcity. Four dugongs fed mainly on the dominant species (*H. ovalis*, *E. acoroides*, *Cymodocea. serrulata*, and *Halodule pinifolia*) available in the catch areas whereas the another two dugongs may have selected their target seagrasses from the existing species. Rhizome appeared to be the importance part of dugong dietary. Remarkably, the dominant available seagrass species in the catch areas contributed to be the most heavily utilized genera of the dugongs in Trang waters.

KEYWORDS: stomach content, dugong, seagrass, Trang Province

INTRODUCTION

Dugongs (Dugong *dugon*), the only extant herbivorous marine mammal in the Indo-Pacific region, inhibit coastal areas with an abundant of seagrasses (Nishiwaki and Marsh, 1985). In Thailand dugongs are rare and they are scattered in small groups in both coastal lines, the Gulf of Thailand and the Andaman Sea. The largest group of dugongs inhabits around Talibong and Muk Islands, Trang Province, Andaman Sea (Aueng et al., 1993; Adulyanukosol et al., 1997, Adulyanukosol, 2000; Hines and Adulyanukosol, 2001). Seagrass beds in Trang Province, the biggest seagrass beds in Thailand (Chansang and Poovachiranon, 1994; Lewmanomont and Supanwanid, 1999), serve as feeding ground for endangered dugongs in Thai waters.

Dugongs feed predominantly on various kinds of seagrass (Heinsohn and Birch, 1972; Johnstone and Hudson, 1981; Marsh et al.,1982; Erftemeijer et al.,1993, Adulyanukosol, 2005; André et al., 2005). The dietary preference of dugongs is mainly based on high total nitrogen (%) levels and low neutral detergent fiber content (de Iongh et al.,1995; Preen, 1995a; Valentines and Heck, 2001). The nitrogen and phosphorus contents of seagrasses are low to moderate, comparable with poor terrestrial pastures (Birch, 1975).

Several studies reported the dietary preference of dugongs for soft and sparse pioneer species such as *H. uninervis*, *Cymodocea* spp. and *H. ovalis* (Gohar, 1957; Heinsohn and Birch, 1972; Johnstone and Hudson, 1981; Aragones, 1994). Heinsohn and Spain (1974) recorded that brown algae, in addition to seagrasses, were eaten by dugongs in North Queensland due to the destruction of seagrass meadows by tropical cyclone. The majority of seagrass species presented in dugong stomach contents (both qualitative and quantitative examination) were found diversely by authors i.e. *Halophila*, *Halodule* and *Cymodocea* (Nair et al.,1975; Adulyanukosol et al., 2005); *H. uninervis* and *C. serrulata* (Heinsohn and Birch, 1972) ; *T. hemprichii*, *H. ovalis* (Johnstone and Hudson, 1981); *Halodule*, *Halophila* and *Cymodocea* (Marsh et al., 1982); *E. acoroides* and *Halophila* (Erftemeijer et al., 1993); *H. ovalis* and *H. uninervis* (Preen,1995a); *Thalassia. hemprichii*, *Cymodocea* spp. and *Syringodium isoetifolium* (André et al., 2005).

In addition, Preen (1995b) reported that dugongs at Moreton Bay, Australia fed primarily on seagrass but ascidians were an important part of their diet which may be caused by nutritional stress. The main food of the dugong in Mandapam, India was *C. serrulata* and the dugongs at the Central Marine Fisheries Research Institute have been fed with *C. serrulata* and *H. uninervis* (Nair et al., 1975). Phuket Marine Biological Center in Thailand reported that captive dugongs preferred *H.*

ovalis among three kinds of offered seagrasses (*H. ovalis, T. hemprichii* and *Cymodocea rotundata*) (Booprakob et al., 1983).

Johnstone and Hudson (1981) stated that the type and abundance of seagrass species in the dugong mounts may be related to the abundance, ecological distribution and energetic value of seagrass species in the catch area. Marsh et al. (1982) concluded that the generic composition of stomach contents probably reflected that of the seagrass beds in the areas when and where the dugongs were captured and was not necessarily indicative of discrimination in selecting food. However, Marsh et al. (1982) did not reject the possibility of preferential feeding of dugongs on specific seagrass species.

The present study is the first attempt to analyze six stomach contents of dugongs received from the largest population of dugong in Trang Province. The obtained information is helpful for understanding the function of dugong in the seagrass ecosystem as well as the conservation and management aspects of dugong population and seagrass resources in Thailand.

MATERIALS AND METHODS

1. Specimens

Six stomach contents of dugongs, four males and two females, were collected from various localities in Trang Province, Andaman Sea, Thailand between January 1997–January 1999 (Fig. 1). All samples were received in the dry season (January to March). The body length of the specimens ranged from 1.67 m to 2.56 m and their body weight ranged from 95 kg to 281 kg. All dugongs, except Du-103, were adult animals. After measuring external characteristics and weighing the dugong carcasses, the internal organs were inspected (measuring, weighing including parasite collecting). The stomach was weighted and the maximum lateral diameter through the oesophagus was measured. Afterward the stomach content was weighed and preserved in 10% formalin sea water. General information of all specimens is given in Table 1 and locality where the dugongs stranded is shown in Fig. 1.

2. Diagnosis the seagrass species

After thorough mixing of each stomach content, 3 sub-samples, about 5 gm wet weight each, were inspected. Samples were identified down to genus/species under stereo-and compound-microscopes based on physio/morphological characters of leaves and epidermal cells of seagrass fragments following the method of Channels and Morrissey (1981) and Adulyanukosol and Poovachiranon (2003). For a diagnosis down to species, it is necessary to know the epidermal cell of the wild plants including additional information from the content i.e. shape of apex or leaf tip, number of venation, mid vein, marginal fibers and serrations. There was no attempt to identify the rhizome and root of seagrass into species so they were grouped as "rhizome". Detritus, rotten seagrass fragments, and unidentified materials were grouped as "others". Algae were treated as a single species. Biomass of each genera/species of seagrass was measured as well. The percentage of frequency of food occurrence and the biomass of each species/ genera were analyzed.

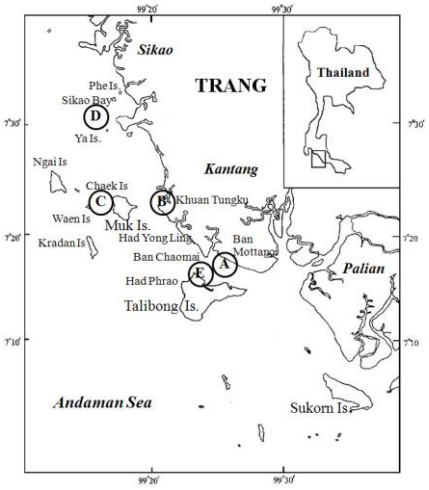

Fig. 1 Coastal area of Trang Province, southern Thailand showing the locations of the samples: A= Du-057 and Du-058, B= Du-059, C= Du-074, D= Du-075, and E= Du-103.

RESULTS

The maximum lateral diameter through the oesophagus ranged from 21cm to 41 cm and weight of the stomach contents ranged from 1.0 kg to 9.4 kg. Conspicuous infestations of nematodes, *Paradujardinia. halichoris*, particularly in the cardiac gland, was found in three dugongs and ranged from 21 to 400 individuals (Table 1). The highest number of this nematode was found in the juvenile dugong (Du-103). There was no sign of cellular reaction on the host tissue surrounding the nematode.

1. Frequency of food occurrence

Nine species of six genera of seagrasses, 4-6 species each, were found from 6 stomachs. *H. ovalis* and *H. pinifolia* including rhizome were present in all 6 dugongs. *C. serrulata* was found in 5 dugongs, followed by *S. isoetifolium* and *T. hemprichii* (4 dugongs each), *E. acoroides* (3

Table 1 Information of the dugongs (Du), catch areas in Trang Province and the stomach contents. Capital letter in parenthesis are equivalent to the location where animal was found in Fig. 1.
(+ indicates the length or weight without head, Sto = Stomach, Lat dia = maximum lateral diameter, Cont = content, nf = not found, - = no information).

Du- (no.)	Date	Location (village, district)	Length (m)	Weight (kg)	**Sex (M/F)**	Sto		% food/ body wt.	Nematode (ind)
						Lat dia (cm)	Cont (kg)		
057 (A)	02/01/97	Ban Chaomai	2.56	281	F	41	9.4	3.35	nf
058 (A)	06/01/97	Ban Chaomai	2.50	245	M	37	5.5	2.24	nf
059 (B)	13/02/97	Ban Khuan Tungku	2.45+	-	M	-	4.0	-	21
074 (C)	25/01/98	Chaek Is-Wean Is.	2.06+	235+	M	38	5.6	-	335
075 (D)	01/03/98	Ya Is.	2.40	246	M	21	1.0	0.41	nf
103 (E)	28/01/99	Had Phroa, Talibong Is.	1.67	95	F	27	3.0	3.16	400

dugongs), *H. uninervis* (2 dugongs), and *C. rotundata* and *H. decipiens* (1 dugong each). Algae were found in all samples except in Du-058 (Table 2).

2. Biomass of each species

The food eaten by the dugongs ranged from 0.41% to 3.35% of their body weights (Table 1). Without the leaf tips of *H. pinifolia* and *H. uninervis*, it is not possible to separate these two species by the epidermal cell features. They were therefore grouped into *Halodule* in Du-074 and Du-075 because leaf tips of both species were found. The biomass of *Halophila decipiens* was not determined because of its scarcity; only one leaf fragment presented in one stomach sub sample of Du-074 (Table 2).

Percentage of dry weight (biomass) of each food species found in the stomachs were; *C. serrulata* 5.06-42.52%, *E. acoroides* 31.76-41.39%, *Halodule* (*H. pinifolia* and *H. uninervis*) 0.84-44.99%, *H. ovalis* 3.11-29.60%, *T. hemprichii* 3.50-28.69%, *S. isoetifolium* 0.42-22.39%, *C. rotundata* 0.47%, and rhizome 11.69-23.17%, algae 0.17-3.78% and polycheate tube 6.77% (Table 2).

The major proportion in the examined stomachs were 4 species of seagrasses: *C. serrulata* and *E. acoroides* (2 animals each), and *H. pinifolia* and *H. ovalis* (1 animal each). *C. serrulata* was found to be the main food of Du-057 and Du-103; followed by *E. acoroides*, *H. ovalis* and *H. pinifolia* in Du-075, and followed by *T. hemprichii*, *H. pinifolia* and *H. ovalis* in Du-103. *E. acoroides* was the dominant food of Du-058 and Du-075; followed by *C. serrulata*, *H. ovalis*, *H. pinifolia*, *S. isoetifolium* and *C. rotundata* in Du-058, and followed by *H. pinifolia*, *H. ovalis*, and *T. hemprichii* in Du-075. The main food in Du-059 was *H. pinifolia*, followed by *C. serrulata*, *H. ovalis* and *T. hemprichii*. *H. ovalis* was the main food found in Du-074, followed by *H. pinifolia*, *S. isoetifolium* and *T. hemprichii*. The majority of rhizomes in each animal were approximately 70% from *H. ovalis*, and followed by 20% from *Halodule* spp. and 10% from other species (visual estimation).

DISCUSSION

Marsh et al. (1982) found some difficulty to distinguish the *C. rotundata* and *T. hempriichii* in Australian samples due to the similarity of their cell features. In contrast those two species of this study had apparently different epidermal cells. The epidermal cells of seagrass leaf in the same species from different localities may not have the same appearance. Therefore it is required to study the epidermal cells of wild plants together with the stomach content samples.

Uchimura et al. (2008) studied DNA including morphological characteristics of *Halophila* species in Japanese waters and confirmed that *H. minor* is a synonym of *H. ovalis*. They also reported that *H. ovalis* in a deep area is *H. major*. However, in this study we did not find any *H. minor* in the stomach contents and identification of seagrass species was based on epidermal cell of seagrass leaf. Adulyanukosol and Poovachiranon, (2003) found the epidermal cell of *H. minor* was different from that of *H. ovalis*. It is necessary to confirm the species of *Halophila* group in Thai waters in the future. Therefore in this study we still use *H. minor*.

1. Frequency of food occurrence

The highest frequency of food occurrence in dugong (qualitative examination) both from the

Table 2 The percentage of biomass of seagrass, algae and polychaete tubes found in stomach contents of dugong. Hp = *Halodule pinifolia*, Hu = *Halodule uninervis*, Ho = *Halophila ovalis*, Hd = *Halophila decipiens*, Th = *Thalassia hemprichii*, Cs = *Cymodocea serrulata*, Cr = *Cymodocea rotundata*, Si = *Syringodium isoetifolium*, Ea = *Enhalus acoroides*, Rhi =Rhizome, Alg = Algae, Pol = Polycheate tube, nf = not found, * leaf tips of both species were found, and ** biomass was not estimated for the Hd.

Species	Percentage of biomass (dry wt) ± S.D					
	Du-057(A)	**Du-058(A)**	**Du-059(B)**	**Du-074©**	**Du-075(D)**	**Du-103(E)**
Hp	4.82±1.77	0.84±0.39	44.99±6.77	23.98±20.84*	12.44±1.98*	11.26±2.09
Hu	Nf	nf	nf			nf
Ho	8.16±1.23	8.75±2.40	9.79±7.69	29.60±8.9	11.99±2.39	3.11±0.88
Hd	Nf	nf	nf	**	nf	nf
Th	Nf	nf	5.52±2.38	3.50±2.13	7.41±4.33	28.69±4.90
Cs	42.52±2.25	24.65±2.41	19.28±17.25	5.06±2.3	nf	35.34±2.63
Cr	Nf	0.47±0.36	nf	nf	nf	nf
Si	0.44±0.12	0.72±0.96	nf	22.39±29.78	nf	0.42±0.17
Ea	31.76±5.79	41.39±7.24	nf	nf	36.49±8.28	nf
Rhi	12.13±4.51	23.17±4.62	18.50±14.90	11.69±7.61	23.09±3.34	20.47±2.22
Alg	0.17±0.09	nf	1.85 ±1.68	3.78±3.29	1.80±-3.13	0.71±0.32
Pol	Nf	nf	nf	nf	6.77±5.88	nf

stomach contents and mouth samples indicated diversity in various studies i.e. *T. hemprichii* and *H. ovalis* (Johnstone and Hudson, 1981); *H. uninervis, C. serrulata* (Heinsohn and Birch, 1972); *Halophila* and *H. uninevis* (Adulyanukosol, 2005); *H. pinifolia* and *H. ovalis* (this study). Eleven species of seagrasses are distributed in the coastal areas of Trang (Table 3). Three species of *Halophila minor*, *Halophila beccarii* and *H. decipiens* were very rare in Trang waters (Chansang and Poovachiranon, 1994; Poovachiranon, 2000; Poovachiranon et al., 2006) and not found in the examined stomachs, except only a tiny fragment of *H. decipiens* was found in Du-074.

2. Biomass of food and the relationship between seagrass species found in the stomach and in surrounding habitat of the catch area

Seagrasses are the principal food of dugongs and small amounts of algae are often eaten. This study and Adulyanukosol et al. (2005), in contrast with Lipkin (1975) and Marsh et al. (1982), found that all algae fragments in the stomach contents were smaller pieces than those of the seagrasses

All samples were assumed to be found close to the areas where they died. The two most common seagrass species in the Andaman Sea coast were *H. ovalis* (85%) and *E. acoroides* (68%) (Chansang and Poovachiranon, 1994; Poovachiranon, 2000; Poovachiranon et al., 2006). Since the intensive studies of seagrass distribution in Trang waters were not available, the seagrass information was gathered from various authors as given in Table 3.

In this study four dugongs (Du-057, 074, 075 and 103) fed mainly on the dominant species (*H. ovalis*, *E. acoroides*, *C. serrulata*, and *H. pinifolia*) available in the catch areas whereas the another two dugongs (Du-058 and 059) may have selected their target seagrasses from the existing species. Rhizome appeared to be the importance part of dugong dietary (Marsh et al., 1982; Anderson, 1998; this study). Three genera (*S. isoetifolium C. rotundata* and *Halodule* spp.) were found in small amounts in the contents of Du-057, 058, 074 and 075 although they were not available in the seagrass information. The dugongs may have fed on these species while traveling into the catch areas, otherwise these seagrass species may be distributed in the areas or nearby areas but they were not found because of their scarcity. Perhaps five seagrass species in Du-074 were distributed along the area of Cheak Island and Wean Island or the nearby islands such as Kradan Island. Since rhizome was one of the major component in the stomach contents (Table 2) and the majority proportion of the rhizome was from *H. ovalis.* Therefore *H. ovalis* was apparently underestimated when rhizome was excluded and it would play an important role in dugong's food as well.

Dugongs were observed to feed in the shallow areas rather than the deeper areas (Adulyanukosol et al., 1997; Adulyanukosol and Thongsukdee, 2003, 2005). That might occur because the biomass of seagrasses in intertidal areas

Table 3 The seagrass species (excluding rhizome) in dugong stomachs are arranged from maximum to minimum by numbering 1-6. Bold characters indicate the dominant species. (Information derived from: Chansang and Poovachiranon, 1994; Aryuthaka and Poovachiranon, 1994; Purintavaragul et al., 1999; Lewmanomont and Supanwanid, 1999; Meesawat, et al., 1999, *Poovachiranon et al., 2006). Hm= *Halophila minor*, Hb= *Halophila beccarii*, and other abbreviations are the same as in Table 2.

Dugong	**Seagrass species in stomach contents**						**(Area)- wild plants**
	1	**2**	**3**	**4**	**5**	**6**	
Du-057	Cs	Ea	Ho	Hp	Si		(A)- **Cs** / Ea, Ho, Hp
Du-058	Ea	Cs	Ho	Hp	Si	Cr	
Du-059	Hp	Cs	Ho	Th			(B)- **Ea, Ho, Th** / Hp, Hu, Cs, Cr, Hm, Hb, Hd, Si
Du-074	Ho	Hp/Hu	Si	Cs	Th		(C)- **Si, Ho, Hp***
Du-075	Ea	Hp/Hu	Ho	Th			(D)- **Ea** / Ho, Hb, Th, Cr
Du-103	Cs	Th	Hp	Ho			(E)- **Cs** / Ea, Ho, Th, Ho, Hu, Hp, Cr, Si

was higher than that of the deeper areas (Nakaoka and Supanwanid, 1999) or it may depend on the difference of nutritive value of seagrass species in space and time (Yamamuro et al. 1999). In mixed seagrass beds dugongs generally selected the fast-growing species, *H. ovalis* and *H. uninervis*, over the slower-growing seagrasses (de Iongh et al., 1995; Vermaat et al., 1995; Preen 1995a; Nakaoka and Aioi, 1999). The feeding trails of dugongs in different places along the coast were remarkably observed mainly on *H. ovalis* beds i.e. Paklok beach in Phuket Island, Sriboya Island in Krabi Province (Adulyanukosol and Thongsukdee, 2003), Muk-Talibong Islands (Mukai et al., 1999), Talibong Island (Nakanishi et al., 2005), and Lidee Island, Satun Province (Supaporn Prempree, personal communication). Although some feeding scars were observed on *E. acoroides*, dugongs were noticed to feed selectively on *H. ovalis* (Nakanishi et al., 2005).

The studies of the nutritive values of seagrass species (i.e. *H. ovalis*, *Halodule*, *Cymodecea*, *T. hemprichii*, *S. isoetifolium* and *E. acoroides*) showed conflicting statements of the values among species (Birch,1975; Heinsohn et al., 1977; Murray et al., 1977; Johnstone and Hudson, 1981, Chirapart and Yamamuro, 1999; Yamamuro et al., 1999, 2004) and further studies are necessary for understanding the nutritive requirement of dugongs.

Sirenians have the highest digestibility coefficient for cellulose (≥80%) of any known mammalian herbivores (Burn, 1986; Aketa et al., 2001), due to an extremely slow rate of passage (Burn, 1986; Lanyon and Marsh, 1995). The apparent digestibility of dugong fed by *H. ovalis*, *H. uninervis* and *Zostera marina* was higher than 81% (Murray et al., 1977; Aketa et al., 2001). This implied that the digestibility of seagrasses between soft and hard species may not have much variation.

Although *E. acoroides* was reported to be not important food for dugongs (Heinsohn and Birch, 1972; Aragones, 1994; and Mukai et al., 1999), one animal of Erftemeijer et al.(1993) study and two animals of this study showed that they fed mainly on *E. acoroides*. Additionally, aerial surveys in 2005 at Muk Island area observed that the individual dugongs were feeding only on *E. acoroides* patches during 3 consecutive survey days (Adulyanukosol and Thongsukdee, 2005). Since the dugongs do not eat the roots of *E. acoroides* and this species is distributed in small patches, this makes it hard to observe the feeding trail in the fields and may lead to misinterpretation. Feeding trails solely on *C. serrulata* meadow were also observed in the deep area (5-6 m depth, unexposed area) at Ka Island, Krabi Province (Poovachiranon unpublished data).

There was incompatible information of food preferences of dugongs and there was no clear conclusion on whether dugongs were selective feeding or not, (i.e. Heinsohn and Birch (1972), Heinsohn and Spain (1974), Heisohn et al. (1977), Marsh et al. (1982), Preen (1993); Erftemeijer et al.(1993). It seemed that *Halophila*, *Halodule*, *Cymodocea*, and *Thalassia* were the main food of dugong. In this study, the dominant available seagrass species in the catch areas (i.e. *H. ovalis*, *E. acoroides*, *C. serrulata*, and *H. pinifolia*) remarkably contributed to the be the most heavily utilized genera of the dugongs in Trang waters. A more reliable indicator of dugong dietary preferences, the studies of the species composition of seagrass beds, feeding trails including the nutritive values of seagrasses and environmental factors in the area of large aggregations of dugongs are recommended.

REFERENCES

Adulyanukosol, K., Chantrapornsyl, S., and Poovachiranon, S. (1997). An aerial survey of dugong (*Dugong dugon*) in Andaman Coast, Thailand. *Thai Fisheries Gazette.* **50(5),** 359-374.

Adulyanukosol, K. (2000). Dugong survey in Thailand. *Biologia Marina Mediterranea.* **7(2),** 191-194.

Adulyanukosol, K, Boukaew, P., and Prasitthipornkul, A. (2005). Analysis of stomach contents of dugongs (*Dugong dugon*) from the Gulf of Thailand. *Proceedings of the SEASTAR Workshop,* 13-15 December 2004, Bangkok, Thailand. 45-51 pp.

Adulyanukosol, K., and Poovachiranon, S. (2003). A pictorial key to genera/species for identification of seagrass cells in stomach contents of dugong from the Andaman Sea, Thailand. Phuket Marine Biological Center. Technical paper no 1/2003. 16 pp.

Adulyanukosol, K., and Thongsukdee, S. (2003). An observation of dugong behaviors from aerial survey and feeding trails of a cow-calf pair in seagrass habitat. *Mahidol University Journal of Environment and Resource*. **1(2):**112-118.

Adulyanukosol, K., and Thongsukdee, S. (2005). Report of the results of the survey on dugong, dolphin, sea turtle, and seagrass in Trang Province. Phuket Marine Biological Center, Department of Marine and Coastal Resources. March 2005. 10 pp.

Aragones, L.V. (1994). Observations on Dugongs at Calauit Island, Busuanga, Palawan, Philippines. *Wildl. Res*. **21,** 709-717.

Aketa, K., Asano, S., Wakai, Y., and Kawamura, A. (2001). Apparent digestibility of eelgrass in dugongs (*Dugong dugon*). *Mamalian Science*. **41(1),** 23-34.

André, J., Gyuris, E., and Lawler, I.R. (2005). Comparison of the diets of sympatric dugongs and green turtles on the Orman Reefs, Torres Strait, Australia. *Wildl. Res.* **32,** 53-62.

Aryuthaka, C., and Poovachiranon, S. (1994). Status of seagrass in Thai waters. In the Fifth Seminar in Marine Science of Thailand in 1994, Rayong Thailand: 22-24 September 1994. 23 pp. X

Aueng, S., Witayasak, W., Lukanawakulra, R., Rearkwisaka, W., and O'Sullivan, P.S. (1993). A survey of dugong in seagrass bed at Changwat Trang. In the Proceedings of the 31st Seminar of Kasetsart University, Thailand: Kasetsart University, Bangkok, Thailand. pp. 363-368.

Birch, W.R. (1975). Some chemical and caloric properties of tropical marine angiosperms compared with those of other plants. *J. Appl. Ecol*. **12,** 201-212.

Boonprakob, U., Chantrapornsyl, S., and Bhatia, O. (1983). Occurrence of dugong (*Dugong dugon*) in coastal waters of Phuket Island and the attempt to keep dugongs in captivity. A Symposium on Marine Mammals of the Indian Ocean, Feb. 22-25, 1983. Colombo, Sri Lanka. 13 pp.

Burn, D.M. (1986). The digestive strategy and efficiency of the West Indian manatee, *Trichechus manatus*. *Comp. Biochem. Physiol*. *A*. **85,** 139-142.

Channells, P., and Morrissey, J. (1981). Technique for analysis of seagrass genera present in dugong stomachs, including a key to north Queensland seagrasses based on cell details. In Marsh, H. (ed.). The Dugong. Proceeding of the Seminar/Workshop of dugong held at the James Cook University, 8-13 May 1979. pp. 176-179.

Chansang, H., and Poovachiranon, S. (1994). The distribution and species composition of seagrass beds along the Andaman sea coast of Thailand. *Phuket Mar. Biol. Cent. Bull*. **59,** 43-52.

Chirapart, A., and Yamamuro, M. (1999). Chemical compositions of seagrasses from Trang, South of Thailand. Proceedings of Effects of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems. Ocean Research Institute, the University of Tokyo. pp. 82-90.

de Iongh, H.H., Wenno, B.J., and Meelis, E. (1995). Seagrass distribution and seasonal biomass changes in relation to dugong grazing in the Moluccas, East Indonesia. *Aquat. Bot*. **50,** 1-19

Erftemeijer, P.L.A., Djunarlin, and Moka, W. (1993). Stomach content analysis of a dugong (*Dugong dugon*) from south Sulawesi, Indonesia. *Aust. J. Mar. Freshwater Res.* **44,** 229-233.

Gohar, H.A.F. (1957). The Red Sea dugong. *Publ. Mar. Biol. Stn. Ghardaqa. Red Sea*. **9,** 3-49.

Hines, E., and Adulyanukosol, K. (2001). Population and habitat assessment of dugong (*Dugong dugon*) off the Andaman coast of Thailand. Final Report submitted to the Ocean Park Conservation Foundation, Ocean Park, Aberdeen, Hong Kong. 10 June 2001. 288 pp.

Heinsohn, G.E., and Birch, W.R. (1972). Foods and feeding habitats of the dugong, *Dugong dugon* (Erxleben), in northern Queensland, Australia. *Mammalia.* **36,** 414-422.

Heinsohn, G.E., and Spain , A.V. (1974). Effect of a tropical cyclone on littoral and biotic communities and on a population of dugongs (*Dugong dugon*, MÜller). *Biol. Conserv*. **6,** 21-23.

Heinsohn, G.E., Wake , J., Marsh, H., and Spain, A.V. (1977). The Dugong (*Dugong dugon*) in the seagrass system. *Aquaculture*. **12,** 235-248.

Johnstone, I.M., and Hudson, B.E.T. (1981). The dugong diet: Mouth sample analysis. *Bull. of Marine Science*. **31(3),** 681-690.

Lanyon, J.M., and Marsh,H. (1995). Digesta passage times in the dugong. *Aust. J. Zool.* **43,** 119-127.

Lipkin, Y. (1975). Food of the Red Sea dugong (*Dugong dugon*) from Sinai. *Israel Journal of Zoology*. **24,** 81-98.

Lewmanomont, K., and Supanwanid, C. (1999). Species composition of seagrasses at Haad Chao Mai National Park, Trang Province, Thailand. Proceedings of Effects of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems. Ocean Research Institute, the University of Tokyo. pp. 43-49.

Marsh, H., Channells, P.W., Heinsohn, G.E., and Morrissey, J. (1982). Analysis of stomach contents of dugongs from Queensland. *Aust. Wildl. Res*. **9,** 55-67.

Meesawat, U., Purintavarakul, C., Mayakul, S., and Hirunpun, R. (1999). Diversity and seasonal anatomical changes of seagrasses at Hat Chao Mai National Park, Trang Province. *Songklanakarin J. Sci. Technol*. **21(1),** 65-81.

Mukai, H., Aioi, K., Lewmanomont, K., Matsumasa, M., Nakaoka, M., Nojima, S., Supanwanid, C., Suzuki, T., and Toyohara, T. (1999). Dugong grazing on *Halophila* beds in Haad Chao Mai National Park, Trang Province, Thailand - How many dugong can survive? Proceedings of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems. Ocean Research Institute, the University of Tokyo. pp. 239-254.

Murray, R.M., Marsh, H., Heinsohn, G.E., and Spain, A.V. (1977). The role of the mid-gut ceacum and large intestine in the digestion of seagrasses by dugong (Mammalia: Sirenia). *Comp. Biochem. Physiol. A*. **56,** 192-203.

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

Nakanishi, Y., Hosoya, S., Nakanishi, Y., Hara, T., and Adulyanukosol, K. (2005). The distribution of dugong trenches in the seagrass beds of Talibong Island, Thailand. Journal Advanced Marine Science and Technology Society. **11(1),** 53-57.

Nakaoka, M., and Aioi, K. (1999). Growth of the seagrass Halophila ovalis at the dugong trails compared to existing within-patch variation in a Thailand intertidal flat. Proceedings of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems. Ocean Research Institute, the University of Tokyo. pp. 255-267.

Nakaoka, M., and Supanwanid, C. (1999). Quantitative estimation of the distribution and biomass of seagrass bed at Had Chao Mai National Park, Trang, Thailand. Proceedings of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems. Ocean Research Institute, the University of Tokyo. pp. 50-65.

Nishiwaki, M., and Marsh, H. (1985). Dugong, *Dugong dugon* (MÜller, 1776). *In* Handbook of Marine Mammals Vol 3: the Sirenians and Baleen Whales. S.H. Ridgway and S.R. Harrison (eds). St Edmundsbury Press Limited, Bury St Edmunds, Suffolk. pp. 1-31.

Poovachiranon, S. (2000). Species composition and their depth distribution of seagrass beds along the Andaman sea coast of Thailand. Biol. Mar. Medit. **7(2),** 412-416.

Preen, A. (1995a). Impacts of dugong foraging on seagrass habitats: observational and experimental evidence for cultivation grazing. *Mar Ecol Prog Ser*. **124,** 201-213.

Preen, A. (1995b). Diet of dugongs: Are they omnivores? *Journal of Mammalogy*. **76(1),** 163-171.

Purintavaragul, C., Meesawat, U., Mayagul, S., and Hirunpun, R. (1999). Seagrasses at Hat Chao Mai National Park, Trang Province, Southern Thailand. *Thai Fisheries Gazette*. **52(2),** 143-149.

Uchimura, M., Faye, E.J., Shimada, S., Inoue ,T., and Nakamura, Y. (2008). A reassessment of Halophila species (Hydrocharitaceae) diversity with special reference to Japanese representatives. *Botanica Marina*. **51,** 258-268.

Valentine, J.F., and Heck, Jr. K.L. (2001). The role of leave nitrogen content in determining turtlegrass (*Thalassia testudinum*) grazing by a generalized herbivore in the northeastern Gulf of Mexico. *J. Exp. Mar. Bio. Ecol*. **258,** 65-86.

Vermaat, J.E., Agawin, N.S.R., Duarte, C.M., Fortes, M.D., Marbà, N., and Uri, J.S. (1995). Meadow maintenance, growth and productivity of a mixed Philippine seagrass bed. *Mar. Ecol. Prog. Ser*. **124,** 215-225.

Yamamuro, M., Aketa, K.,and Uchida, S. (2004). Carbon and nitrogen stable isotope ratios of the tissues and gut contents of a dugong from the temperate coast of Japan. *Mammal Study*. **29,** 179-183.

Yamamuro, M., Umezawa, Y., and Koike, I. (1999). Temporal change in nutrient contents and stable isotope ratios of *Halophila ovalis* growing at intertidal flat. Proceedings of Effects of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems. Ocean Research Institute, the University of Tokyo. pp. 43-49.